CHAPTER IV

WATER SUPPLY

4.1 Basic Guidelines for Water Supply

Water production and supply facilities will be designed on the basis of the following guidelines

(1) Basic Guidelines

a) Provision of a safe and stable water supply through the design year to the designated areas

b) Due consideration of operation and maintenance in design of a rational and reliable water supply system

c) Effective water utilization

d) Consistency with planning for related water supply projects

(2) Water Supply Facilities Safety

a) Through safeguards against fire and other hazards

b) Prevention of negative environmental impacts potentially caused by noise, vibration and drainage from water supply facilities

c) Capacity for response to future potential environmental charges

(3) Machinery and Equipment for Water Supply Facilities

a) Long-term machinery and equipment life

b) No adverse impacts on water quality

c) Simple operation and maintenance

d) Adaption to environmental requirements

4.1.1 Water Sources

The water source is to be the groundwater developed by EMPAGUA as part of the Emergency Plan. The seven blocks of potential aquifers were identified on the basis of the results for the geological survey, electrical prospecting and test pump-up for test wells. Of these, blocks were then selected in consideration of the regions where there are either chronic water shortages or where residential development is rapidly occurring, and several blocks adjacent to these areas were selected to

have new wells that will be linked to the existing facilities as part of this plan.

The five well groups that were ultimately selected were located in Zone 17 and 18.

The total number of wells to be dug is determined in agreement with the planned pump-up volume under Emergency Plan I.

4.1.2 Water Convenyence

(1) On the basis of the water supply requirements for the design years 1990, 1995 and 2000, several wells are to be as close as possible to each other, and so that they can be linked to the existing facilities with the minimum of additional expenses for land acquisition, while at the same time being located so that the water can be distributed by gravity to nearby purification plants or pumping stations.

(2) Existing treatment plants near the proposed well fields are Santa Luisa and Las Ilusiones. There are also pumping stations at Canalitos and Juana de Arco. Several alternative conveyance configurations were formulated on the basis of geographic and topographic factors and beneficiary area location, and the final conveyance plan was selected following study of the alternatives. The number of booster pumps was minimized and the reserve capacity was eliminated given the urgency for the prompt implementation of this emergency Plan.

(3) The type of conveyance pipeline was selected on the basis of a comparative study of the types of pipe that are currently in general use.

4.1.3 Connection to Existing Facilities

As discussed in section 4.1.2 above, conveyance pipelines from well fields are in general to connect with storage tanks at nearby existing plant facilities (or be routed to sites of future planned tank construction). Where existing conveyance pipeline is nearby, wells under the Project will be directly connected thereto.

Existing facilities in the vicinity of the proposed groundwater development are the Santa Luisa and Las Ilusiones plants, Acatan tank, and Project 4-4 and Juan de Arco pump stations.

Further planned tank facilities are at San Gaspar in Zone 16 and Finca El Rodes in Zone 18.

Existing conveyance pipeline in the vicinity of wellfields is the network from Lo de Coy to Vacan de Arco, the pipeline from Teociente dam to the Santa Luisa plant, and the pipeline from project 4-4 to Cerro de Carmen.

4.2 Rehabilitation of Existing Wells

EMPAGUA owns 57 wells in the Metropolitan Guatemala area. However, a number of these wells are currently not in operation because of low productivity due to factors of general super annuation, clogged strainers, damage suffered during the 1976 earthquake, etc. A rehabilitation program for these wells is currently being studied.

At present 22 wells are planned for rehabilitation in order to achieve an additional production of 0.382m^3/sec.

These wells were selected from existing ones in consideration of their productivity, more than 20 l/sec.

A detailed rehabilitation program was researched by preliminary study, APPENDIX-V.

4.3 Operation and Maintenance

4.3.1 Basic Approach

Operation is defined as consisting of management of (i) water quantity and quality, (ii) labor safety, (iii) equipment operation and (iv) energy consumption. Maintenance is considered as comprising equipment and facility inspection, upkeep and repair.

The proposed project envisages new well construction necessary conveyance pipeline and other appurtenant facilities for potable water delivery to EMPAGUA's existing service system. As a result, operation and maintenance for both existing and proposed production conveyance facilities must be integrated into a single O/M structure.

The following criteria are cited as necessary for effective operation and maintenance:

i) Establishment of facility management offices
ii) Institutional strengthening of the O/M structure
iii) Increase in number of O/M technicians are specialists, and thorough traning thereof
iv) Provision of suitably equipped maintenance and repair workshop facilities and adequate staffing thereof
v) Preparation and filing of design drawings for equipment and facilities
vi) Deployment of necessary vehicles for equipment inspection and maintenance

General attention will be given to the nature of the existing EMPAGUA institutional structure in determining the framework for facility management offices and O/M organizational requirements for facilities envisioned under the Project.

4.3.2 Operation Plan

Principal facilities under the Project consist of electro-mechanical equipment for wells, water conveyance and necessary power transmission lines and substations.

Specifically, mechanical equipment comprises deep well pumps, booster pumps and regulating equipment; while electrical equipment includes electrical construction equipment, power distribution and substation facilities and equipment, and security devices.

Operational procedures are broadly classified into water volume control, water quality control and power consumption management.

(1) Water volume control consists of demand forecasting, gauging (water volume, pressure and level) and regulation. The principal points for attention area:

a) Preparation of operation manuals and thorough education of staff in the contents thereof
b) Prevention of leakage; power economization
c) Replacement of old pipeline

(2) Water quality control sensers to ensure that supplied water meets accepted standards for potability. Important points are:

a) Preparation of water quality control manuals

b) Avoidance of mixture of groundwater with river water during conveyance to treatment plants

(3) Power consumption management seeks to establish optimum equipment operating efficiency, and will have sensors as a safeguard against equipment breakdown. Important points are:

a) Thorough education of staff in contents of equipment operating manuals, particularly with regards to power requirements, and close supervision of equippment operation

b) Maintenance of detailed records of equipment operation, inspection, maintenance and repair

c) Maintenance of a daily operations logs

d) Maintenance of inventory record for each item of equipment

4.3.3 Operation System

Project facilities would be operated under directives by EMPAGUA's O/M department main office to the new facilities management offices to be established under the Project. Instructions would subsequently be issued from these offices to the relevant sub-offices where the actual operation of production facilities would be undertaken by permanent personnel.

Operations personnel would bear in mind the following points:

a) Operational safety

b) Thorough grasp of functions of all eqipment; careful monitoring of regulating gauges

c) Confirmation of acceptable water quality

d) Regular inspection of equipment

e) Thorough grasp of emergency procedures in the event of fire or accident

Types of mechanical and other non-electrical facilities and equipment:

a) submersible motor pump
b) storage tank
c) booster pump
d) regulating equipment
e) conveyance pipe

Electrical facilities:

a) electrical equipment
b) substation facilities
c) power distribution facilities
d) security devices

4.3.4 Water Quality Management

A deep aquifer is required for the water source and so the primary condition is that the mixing-in of river water be prevented.

Debacterization treatment is in principle performed through chlorine gas debacterization with chlorination facilities being provided at the conveyance terminals of each conveyance system.

However, individual treatment facilities are to be provided for remote wells for which abnormal values are indicated for the raw water testing performed when the well is dug.

In order that management of the water quality be performed to meet the suitable water quality standards, it will be necessary to perform the following.

- Determine the items for which water quality management is to be performed.
- Implement daily checking of the water quality (by determining the provision of the measurement facilities and the intervals for measurement)
- Determine the amounts of processing chemicals to be added (correcting the amounts added)
- Planning the safety of chemical treatment
- Management of the chemical inventory (chemical ordering and delivery plan, quality and ratings checking, storage and adjustment)

4.3.5 Maintenance Plan

Facilities and equipment life are estimated as follows:

well life:	30 years
pump life:	16 years
pipeline life:	50 years
structure life:	30 years

Salient points of the maintenance plan are as follows:

(1) Objective of Facility Maintenance

The objective of facility maintenance is to ensure the capability of the said facilities to deliver to areas of consumption a stable water supply at proper pressure and of quality in keeping with accepted standards for potability.

(2) Maintenance Components

Maintenance operations comprise inspection, maintenance, repair and protection of facilities and eqipment.

(3) Maintenance Approach

a) Inspection: Inspection method and sequence is determined. Inspections comprise both regular inspections and those conducted at times of emergnecy only.

b) Maintenance: Maintenance includes periodic lubrication, cleaning, care overhaul, etc. of equipment and facilities as required, as well as emergency maintenance measures in response to irregularities identified through inspections. Care is necessary to keep on hand an adequate inventory of maintenance equipment and spare parts.

(4) Preparation and filing of design drawings for equiment and facilities

(5) In order to effectively maintain facilities and equipment, it is necessary to standardize inspection and other maintenance procedures, and implement said procedures in a uniform manner. For this purpose, maintenance manuals should be prepared.

Operational procedures should likewise be standardized, and water volume, water quality and other quantitative and qualitative factors carefully monitored, regulated and recorded.

Procedures for rapid response to accidents during operation must be formulated, to minimize advanse impact on the facilities and equipment.

4.3.6 Maintenance System

The causes of accidents may be due to technical errors, institutional or structural inconsistencies, levels of staff trainer and staff morale, inadequacies in the quality of facilities and equipment, etc.

Measures for prevention of accidents center on avoiding of equipment and facility over-use, and implementation of thorough inspection and monitoring procedurs.

Maintenance procedures are carried out under the O/M organization described subsequently in section 4.3.7.

Facilities and equipment requiring remaining maintenance are as follows.

- wells
- pumps and motors
- electrical facilities and eqipment
- pipeline
- structures

4.3.7 O/M Organization

Operation and maintenance under the Project is to be directed by the facilities management officies.

In order to realize Project benefits as promptly as possible, well fields are to be ranked blockwise for priority of well construction and pipeline construction with existing facilities. Consequently O/M will include measures taken during facility construction, and Procedures followed after completion of the production system envisaged under the Project.

(1) Existing EMPAGUA Structure

The EMPAGUA O/M department is administratively within the technical division. The O/M department oversees 6 facilities management offices and an electro-mechanical maintenance section.

The well and pump management office is staffed with 71 persons. Staff breakdown is clerical: 3; pump facility operators: 54; boring equipment operators: 6; pump assembly: 1; drivers: 3, and security and custodial: 4.

The electro mechanical maintenance section is staffed with 25 persons. Staff breakdown is managers: 1; assistant managers: 1, secretaries: 1'; electrician: 4; lubrication specialist: 1; assistant electricians: 8; pump motor mechanics: 1; welding: 2; lathe operators: 1; assistant lathe operators: 1; chemists: 1; assistant chemists: 1; security: 1.

(2) Maintenance Measures During Construction

Maintenance measures during construction of facilities under the Project are to be implemented under EMPAGUA's existing structure. Taking into consideration personnel requirements following completion of Project facilities, a training program should be formulated to expand technical staff for participation in construction supervision. As facility design, construction and maintenance are fundamentally inter-related, the said training program would thoroughly familiarize staff with facility and equipment design and function, operational procedures, inspection and maintenance procedures, etc.

The said trained staff would be present at and participate in the supervision of the following:

a) well construction
b) pump installation
c) pipeline construction
d) tank construction
e) connection with existing facilities
f) pump station construction
g) electro-mechanical equipment installation; etc.

As well field construction is to be completed according to a block-wise sequence of priority, following completion of facilities for an entire block, the maintenance responsibilities for that block would be assumed by the relevant facilities management office to be created under the Project.

(3) Facilities Management Offices

Operation of water production and supply facilities can be broadly categorized into i) water valume control, ii) water quality control, and iii) power consumption management. Effective operation requires further establishment of a properly equipped workshop.

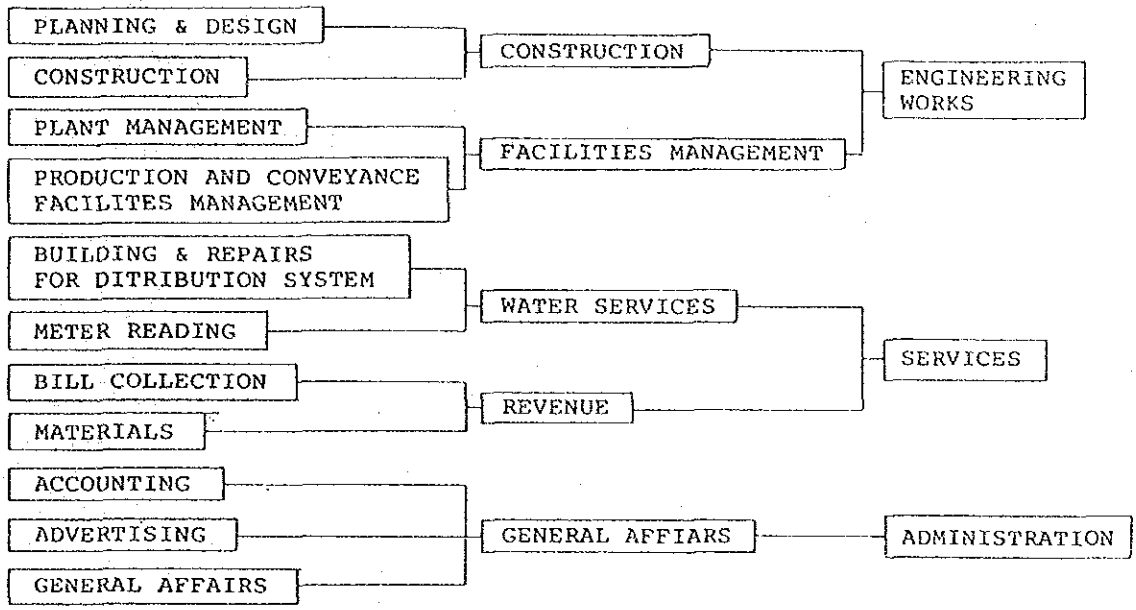
The facilities management office accordingly requires the personnel and facilities to effect the above described operational aspects. As the number of new wells envisioned is almost equivalent to the number of existing EMPAGUA wells, it is proposed that several facilities management offices be established under the Project. Such offices would also carried out the functions of the electro-mechanical maintenance section.

At alternative proposal is to strengthen the existing EMPAGUA structure overseeing operation of plants to which new groundwater is to be delivered, and have the said structure assume responsibility for operation of the facilities to be constructed under the Project.

(4) Duties and Responsibilities

Operation is considered as consisting of water volume control, water quality control, labor safety management, operational management, and power consumption management. Maintenance comprising inspection and equipment upkeep procedures.

Accordingly, O/M is to be institutionally organized as follows:



At present, EMPAGUA is institutionally separated into two divisions which oversee a total of 6 departments and one special unit. Grouping of duties for facilities management in the above manner was done in considerations of the nature of EMPAGUA's existing organizational framework.

An alternative to the establishment of new facilities management offices would be to strengthen the existing EMPAGUA plant supervision structure, and establish responsibility for O/M of envisired facilities under the said structure. In order to carry out these additional responsibilities, an administrative manager, technical manager and maintenance manager would be appointed under the current plant manager. The administrative manager in turn would be assisted by a secretary, general affairs clerk, accountant, driver, and handyman. The technical manager would oversee facility and equipment operation and water quality survey. They would have the services of an assistant engineer, safety officer, water distribution specialist, surveyor and

draftsman. Facility and equipment maintenance would be the responsibility of the maintenance manager who would supervise workshop activities with the assitance of a repair mechanic, materials oversees and, warehouse overseers, and security guards.

Work would be performed in either 2 or 3 shifts per day.

FIG. 4-1

EXISTING FACILITIES

AGUACATE
LA BRIGADA
EL MOLINO
LO DE COY
TP-9
TP-1
TP-2
TP-3
TP-4
T-4.4
CERRO DEL CARMEN
EL GUARDA
ACATAN
LAS ILUSIONES
ATLANTICO
JUANA DE ARCO
T/P JUANA DE ARCO
CANALITOS
SANTA LUISA
AGUA BONITA
EL CAMBRAY
HINCAPIE
CERRO GORDO
LAS MINAS
OJO DE AGUA
TEOCINTE

N

LEGEND

- TREATMENT PLANT
- DISTRIBUTION TANK
- CONDUCTION PIPE LINE

SCALE 1:100,000
0 1 2 3 4 5km

REPUBLIC OF GUATEMALA MUNICIPAL WATER SUPPLY CORPORATION OF GUATEMALA CITY (EMPAGUA)	
GROUNDWATER DEVELOPMENT PROJECT	
EXISTING FACILITIES	
DATE: 1986	DWG.NO.: 3
JAPAN INTERNATIONAL COOPERATION AGENCY	

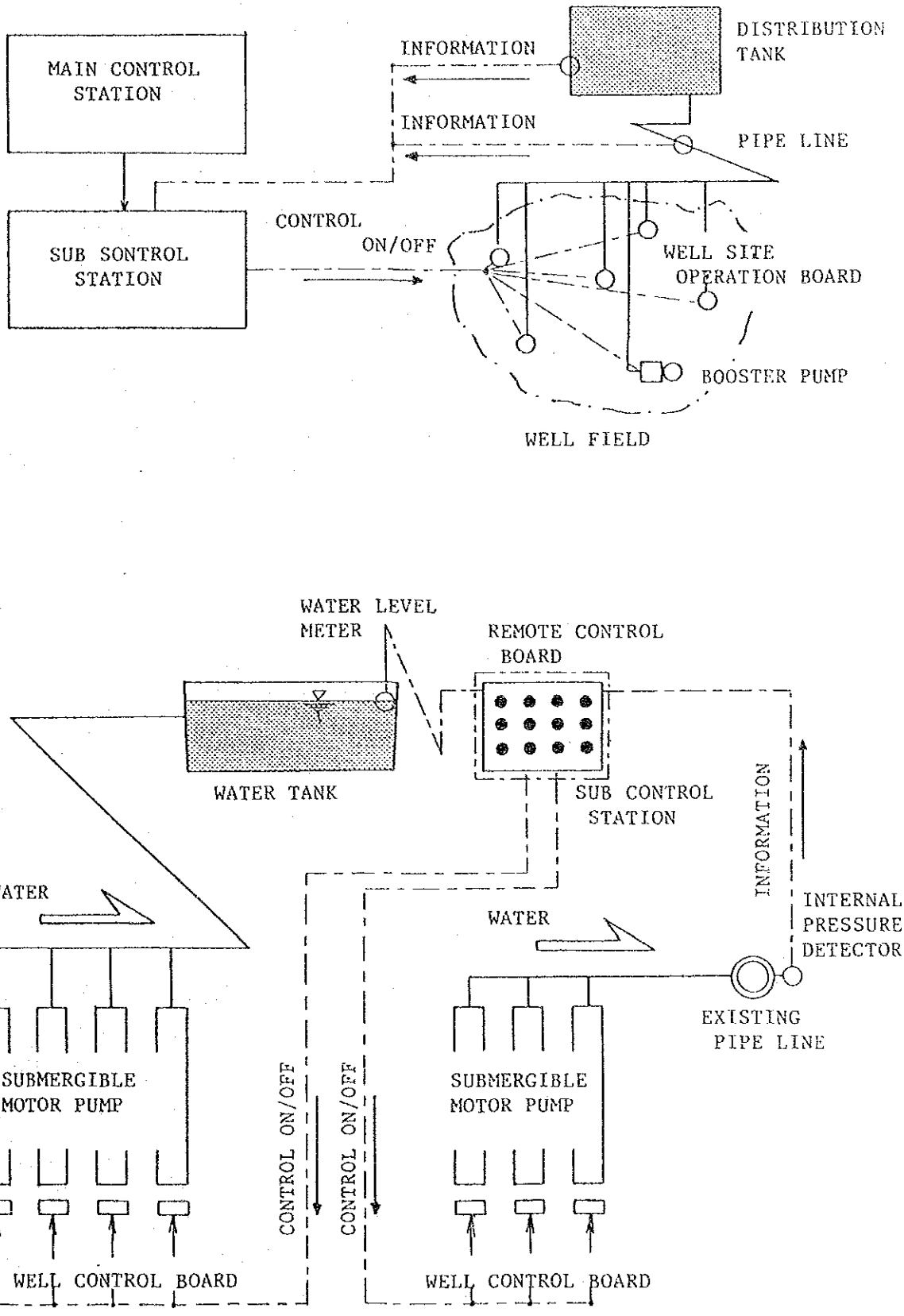


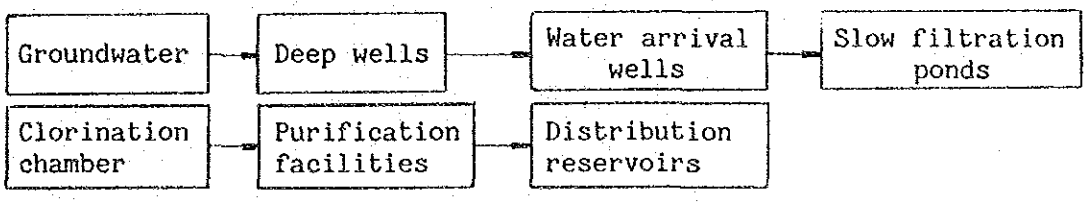
FIG. 4-2 OPERATION FLOW CHART

CHAPTER V

WATER SUPPLY FACILITIES

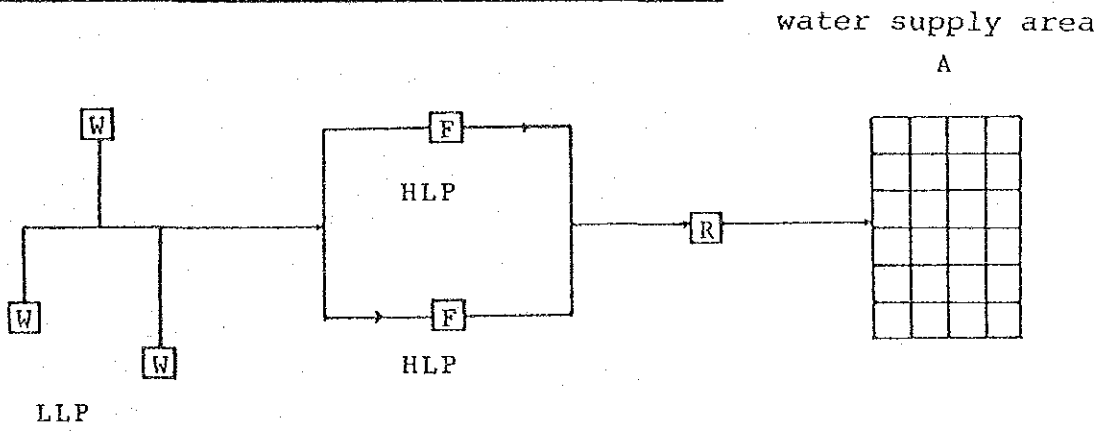
5.1 Well Groups

The water source for drinking water supply is to be groundwater. When groundwater is used as a water source, the standards for the locations of the system facilities between the water intake point and the point of water distribution are generally as shown in the diagram below.



In addition, the following diagram is given as an example of the water conveyance facilities from the point of water intake. There are many actual examples where the water purification facilities are omitted when groundwater is used as the water source. This plan however, includes the purification facilities, tanks, existing pipes and also the nearby facilities.

Example: Conducting Water from Intake Facilities



W : Well
LLP: Raw water lift pump
F : Purification plant
HLP: Water distribution pump
R : Water distribution plant

5.1.1 Features of Well Groups

The hydraulic boundaries divide the area into eastern, southern and northern sectors and the groundwater development potential for each of these sectors was used as the basis for an evaluation of the priority for development plan implementation, with the eastern sector being the Development Plan Priority Sector, and with 8 sections within the southern sector being selected as candidate sections for well groups in this development plan by the hydrogeological study.

The well groups of I Canalitos, II Lavarreda, III Compode Ocotes, IV El Rodeo, V La del Rodrigues and VI Hermosa were selected in the eastern sector, and the two additional blocks of VII Norte and VIII Chinautla being chosen from the northern sector to make a total of eight. The following will be a description of the hydraulic features of these well groups according to their respective blocks (Refer to Appendix-II GROUND WATER).

(1) Canalitos (Block I)

This block is near to the Santa Luisa purification plant and the topography is that of a relatively gentle plateau.

This block is situated at the southern portion of the eastern sector basin formation. Electrical prospecting and groundwater level data imply the presence of a groundwater artery extending along the approximately 2 km wide graben oriented SW-NE. Quarternary sediments in the area are 150-250 m thick. The water level of an upper aquifer is 70-120m, and assumed to flow into the graben from the southwest. Test well No. 2 indicates lower aquifer below EL 1300 m, and furthermore, the graben formation described above suggests basement fracturing that indicates the possible presence of a good aquifer.

(2) Lavarreda (Block II)

This is located close to the Juana de Arco pumping station and tank 4-4, and the topography is that of highland. This block

is situated at the southern portion of the eastern sector basin formation. Electrical prospecting and groundwater level data imply the presence of an underground basin formation approximately 4 km in diameter, with groundwater outflow to the southeast. The basin is considered as being fed with an upper aquifer from the north and west. Although the thickness of the Quarternary deposits has not yet been determined, it is estimated at 150 - 300 m on the basis of the geological characteristics in the vicinity. Water level of an upper quifer is considered to be 70 - 120 m.

Although the presence of an upper aquifer has yet to be confirmed, the existence of north-south and east-west faulting in the area leads to the conclusion that fracturing of the basement is extensive, and a lower aquifer below EL 1300 m may be expected. A depth of about 300 m is necessary if the lower aquifer is to be taken as the object for development.

(3) Compo de Ocotes (Block III)

This block is in the central reaches of the Ocotes River that flows eastwest and is thought to have underground water in the east-west and north-east directions. It is a region in which the upper aquifers from the previously described Block I and II, and the southern highland region converge.

The topography is complex and the existing arteries have a steep slope and many convolutions.

Although the thickness of Quarternary deposits forming the lower aquifer has not been confirmed, the relatively low ground elevation suggests a thickness of 150 - 250 m.

A north-south fault is present in the eastern portion of the block and corresponds to an extension of the northeast-southwest underground through formation in Block I as described above, and the east-west faulting in Block II. Extensive fracturing of the basement is therefore anticipated and the presence of a lower aquifer is considered likely.

(4) El Rodeo (Block IV)

This block is in Zone 18 which is the main area for water distribution. This block is situated outside the northeastern boundary of the eastern sector basin formation. Results of electric prospecting and evaluation of the groundwater level and those of Test #1 indicate that the basement lies a relatively shallow depth in Block IV, and is thought to be an upheaval block overall. The main recharge area of the upper aquifer is thought to be the relatively small-scale mountainous region to the north. Although the aquifer flows down from this region, the recharge volume is small. Despite the fact that the test well confirmed the presence of an upper aquifer in this sector, the pump-up potential is very small at around 5 l/sec, and leads to the conclusion that the basement has little fracturing.

Because of this, the implementation of detailed geological surveys to confirm the presence of the lower aquifer should be conducted prior to the implementation of test boring for the development of this block.

(5) Rio Los Octes (Block V)

This block is in the eastern block marked by National Highway No. CA-9 and is situated on the northeastern boundary of the eastern basin formation. Its geological structure shows it to belong to the eastern graben part of the fault running north-south. this also appears in the landform as a steep cliff extending north-south. This also appears in the landform as a steep cliff extending north-south, and for which the eastern side is about 100 m lower with an elevation of around 1,200 m.

The upper aquifer of this block is downstream from Block III and is thought to be formed from inflow from the hilly rgion to the south, and from part of the western-side upper aquifer that resurfaces from below EL 1,300 m along the north-south cliff.

Test well No. 3 boring indicated a depth of 240 m for the thickness of the Quarternary sediments in this block, and a depth of 50 m for the level of the upper aquifier. As yet, the

presence of a confined aquifer remains unconfirmed for this block. A look at the landform conditions indicates that the unconfined aquifer should be made the object of develoment. Furthermore, the water produced would have to be conducted a considerable distance and the difference in elevation would mean that this would have to be performed under pressure.

(6) Hermosa (Block VI)

There is much residential development on the highland part of this block where national highway CA-1 from the urban area meets the mountainous region in the east. The elevation is approximately 1,500 m.

The Quarternary sediment strata (volcanic ash deposits) of this sector are approximately 200-250 meters in thickness and the unconfined aquifer indicates a groundwater depth of 51 m and is thought to flow to the north.

(7) Norte (Block VII)

This block is situated on the northern plateau of the northern basin formation of this block, and is a plateau having an elevation of around 1,400 m. However, the landform is interrupted by a river system running north-south. There is a fairly wide distribution of the limestone outcrops that constitute the basement in this block and the Quarternary sediments are not more than thinly deposited sediments in a basin. Results of the Project 4.3 boring indicated that the upper aquifer has a water head at EL 1300 m and that the pump-up volume is 63 l/sec. Geologically speaking, the block contains the north-south fault and fissure zones concentrating in the northeast-southwest directions to provide conditions that suggest the existence of a lower aquifer.

Development for this block should therefore be implemented with the lower aquifer as the object. A depth of 250 m is desirable since a great many wells have been brought into operation in recent years and it is necessary to have this depth so that they do not interfere with each other.

(8) Chinautla (Block VIII)

The part in the western side of Norte (Block VI) is a plateau that has an elevation of about 1,400 m, sloping to the north-east with river development along the gradient. In the west, the elevation is 1,600 m and consists of andesite (Cerro El Naranjo). The thickness of the Quarternary sediments is estimated to be less than 100 m from the results of electric prospecting. Supply to the upper aquifer of this block is from the western highlands mentioned above while there is also some from the south. The geological structure of this block is such that there are northeast-southwest fissures, thus indicating the presence of an upper aquifer. Furthermore, the presence of groundwater is expected since in this block there is a beer factory that uses groundwater as a water source.

However, there is a great distance to any existing facilities and there are also the difficulties of the development progress that has been made for the reiver valleys.

5.1.2 Determining the Well Groups

The proposed well groups were determined using electric probing and the results of this and those of other tests led to 7 well groups being initially selected.

Of these, a comparison of the technical and economic aspects of the conveyance routes with respect to the area for water supply led to five groups being selected.

These five groups are the Canalitos (Block I, III), Lavarreda, El Rodeo and Norte groups. Two of the groups excluded were the Lo de Rodriguez and the Chinautla groups that were too far from the existing facilities of EMPAGUA as regards the topography and its influence upon water conveyance.

These excluded well groups however, are candidate sites having promising aquifers could be incorporated into future groundwater development projects.

Additionally, Hermosa block which is on the west side of Canalitos block is considered to have potential for new demand, and a total of 6 well blocks were finally selected for the target area.

5.1.3 Yield Potentiality in the Project Area

Available development yield in each wells is determined by following conditions.

- geological condition, road network, existing pipeline network and demand potentiality.
- yield potentiality of one well

Development yield of the project is considered as follows by estimated potentiality recommended the study of ground water.

Block	Estimated Potential (l/s)	Existing Yield (l/s)	Development Potential Yield (l/s)	Estimated Well No	Estimated Well Yield (l/s)	Average Well Yield (l/s)	Terget Total Yield (l/s)
Canalitos	492 + 284 = 776	24	752	17	44	30	510
Lavarreda	358	35	323	2	161	35	70
Norte	568	260*	308	8	39	35	280
Dl Rodeo	336	8	328	7	46	20	140
Hermosa	245	23	222	4	55	30	120

* Existing yield of 260 l/s is calculated with rehabilitation plan of EMPAGUA.

5.2 Selection of Deep Well Pumps

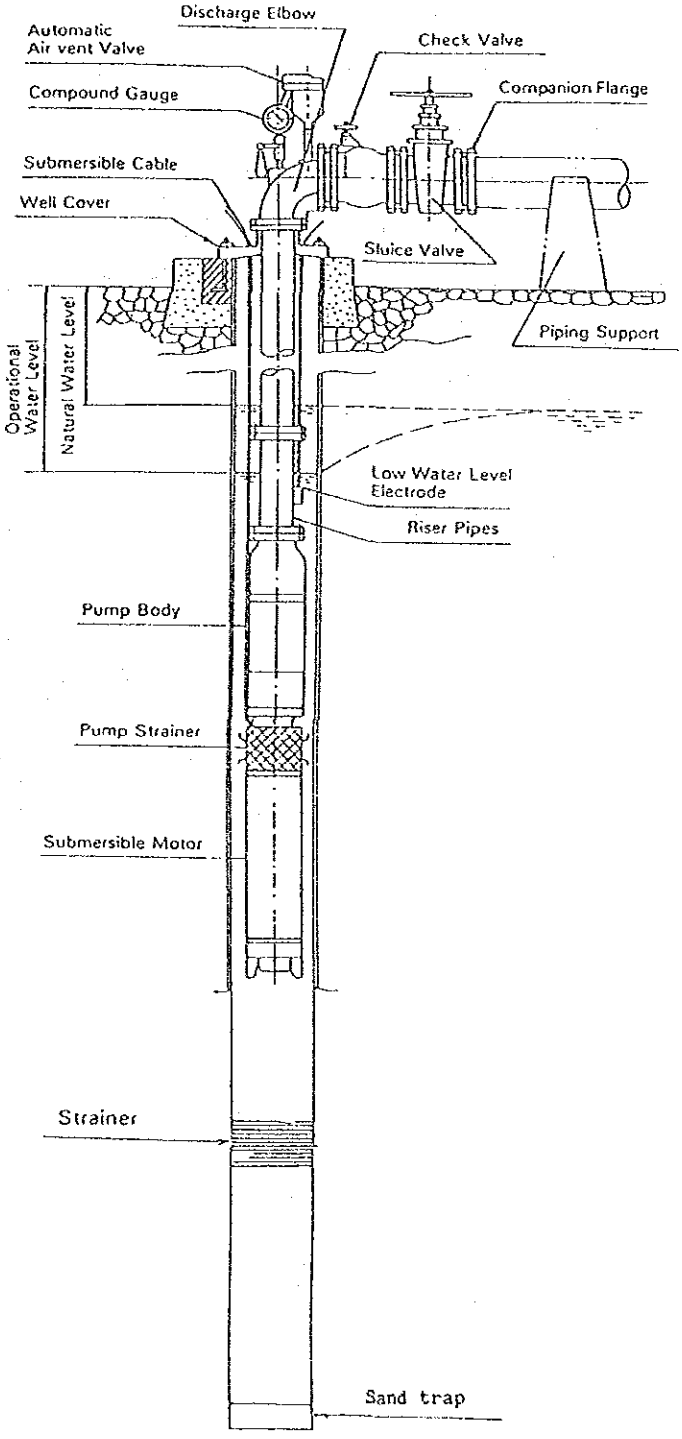
The well groups are planned to pump-up water from the confined aquifer as part of a plan using deep well pumps. The types of pumps that can be used include air lift pumps, bore hole pumps and submersible motor pumps, etc. The air lift pumps will be generally used for the pipe diameters of 100 mm or less and the pump-up efficiency will not be good. Moreover, the bore hole pumps have a more complex structure and the placement also requires troublesome considerations so, compared to submersible mortor pumps, furthermore, the pumping efficiency deteriorates for higher water head. Unless there are any other special conditinos, air lift or similar types of pumps are not being generally used for wells.

Submersible pumps are selected for the project as the result of the following comparison with bore hole pumps.

	Submersible Motor Pumps	Bore Hole Pumps
- Operation Space required on the ground	Small	Wide
- Periodic Maintenance	nil	Ground packing Adjustment Check of Vibration
- Pump setting	easy	difficult
- Pump up efficiency	good	not good
- Required horsepower	low	high
- Cost	cheap	high
- Running cost	cheap	high

(1) Structure of Deep Wells

The structure of deep wells is indicated in the following figure.



The phisical features of the well structure for standard design are as follows.

- Well diameter	More than 438 mm (17-1/2")
- Casing diameter	300 mm (12")
material	SGPW or STPW
thickness	8 mm
- Riser pipe diameter	150 mm (6")
- Depth of the well	300 - 350 m
- Depth of the pump setting	210 m
- Sealing material	Clay or Cement milk
- Gravel packing material	River gravel 2 - 5 mm
- Strainer	Stainless Steel (Johnson type) ø300 mm No. 40 - No. 60 ℓ = 30 m
- Sand trap	5 m

(2) Features of Submersible Motor Pumps

Submersible motor pumps do not require the provision of a pump room on the ground since only the discharge elbow and the cable are exposed on the surface, with the pump itself, the motor and the riser pipe being installed within the well. The submersible motor therefore has a fairly compact design and any voltage rises that occur during operation either cause the current to increase, or have practically no effect upon the current, whereas they would cause the current to drop in the case of a normal motor for general use. The permissible range of voltage fluctuation is ±10%. Another advantage is that they produce no vibration or noise during operation, and that smooth operation is still possible even there if there is a slight bend in the well.

The bearing metal and thrust receivers are all water-lubricated to eliminate the need for oiling, and therefore do not contaminate the groundwater.

In addition to having these features mentioned above, these motors also have a simple structure and have full exchangeability of parts. Disassembly is easy and parts exchange and repair is also possible. These motors are easy to maintain.

(3) Casing

The material of the casing is normally used steel having a thickness of 8 mm, while the connection between the casing and the strainer is either a welded connection or a screw connection. Welded connections will be used since this is the most general method.

(4) Strainer

Strainer position will be determined following identification of aquifer location and thicknes through test boring and electric propecting.

The lower extremely of the casing pipe is to be closed, with the space between the strainer and closed pipe and to serve as a sand trap.

The structure of the strainer can either have round holes, vertical slits or a continuous horizontal V-slot. It is also desirable that a wire screen be wrapped around the round hole and vertical slit types.

Strainer aperture density is to be 15% of total strainer surface, and its length will be determined on the basis of aquifer thickness. For the purposes of planning at this stage, strainer length is tentatively calculated at 30m and 40m.

5.3 Conveyance Pipeline Selection

There are many types of conveyance pipes available and it is desirable that pipe selection made in accordance with the conditions for the installation. The list of the major types of pipes and their respective features is shown in TABLE 5-1.

The pipes were proposed according to their features as shown in the above table, with the use of ductile cast iron pipes being selected because of structure and maintenance advantages that make them suitable for when the well groups are remote from cities, and when the pipes have to pass through hilly and mountainous regions.

5.4 Conveyance Pipe Route Selection

5.4.1 Conveyance Route

(1) The following are the items that need to be considered when determining the route of conveyance pipes.

1) Ease or difficulty of using existing facilities in the water service region.
2) Ease or difficulty of land acqusition
3) Quality of the groundwater
4) Scale of the necessary earthworks
5) Scale or difficulty of acquiring and transporting materials
6) Whether or not maintenance and management can be performed easily and safely after completion
7) Whether the construction expenses are low, and whether the long-term functions can be maintained

(2) Existing Faciliites in the Water Service Area

The following are the items that need to be considered for optimum integration of the existing facilities and the newly-laid conveyance pipe system.

1) Planned facilities and exiting facilities in the city
   - Santa Luisa purification plant
   - Acatan Tank
   - San Gaspey Tank (being planned)
   - Tank 4-4
   - Cerro de Carmen

2) Planned facilities and existing facilities in Zone 18
   - Las Ilusiones purification plant
   - Juana de Arco pumping station
   - Tank 4
   - San, Rafael La Lagune Tank (being planned)
     (Finca El Rodeo)

3) Other facilities
   - Canalitos pumping station
   - Teociente Dam - Santa Luisa purification plant pipeline
   - Tank Agua Bonita
   - Planta El Cambray pipeline

(3) Conveyance Route Proposals

The following is proposed concerning the direction of water conveyance for the well groups.

1) Canalitos
   - Conveyance to the Acatan Tank
   - Connection to the Teocinte-Santa Luisa pipeline and conveyance to the Santa Luisa Treatment Plant
   - Constructio of a tank at San Gasper as part of the future plan
   - Conveyance to the Juana de Arco Treatment Plant via close to the Canalitos Treatment Plant

2) Lavarreda

- Connection to the existing pipeline and connveyance to the Juana de Arco Treatment Plant

3) El Rodeo

- Conveyance to the Las Ilusiones Treatment Plant
- Connection to the existing conveyance pipeline at Las Ilusiones
- Pumping up to a tank provided on elevated land within the region

4) Norte

- Conveying the water of the well groups to Tank 4-4
- Conveying the water from Tank 4-4 to the Juana de Arco Treatment Plant

5) Hermosa

This block contains well sites close to the terminus of the Tank Agua Bonita distribution network, as well as sites proximate to the Planta El Cambray distribution network. Consequently, two wells are to be connected with a proposed tank at San Lazaro, while the remaining two wells are to be connected with the El Cambray distribution pipe.

5.4.2 Selection of the Conveyance Route

(1) Comparison of the proposals

Technical and economic investigations were performed for the well groups, the number of wells to be dug and the direction of conveyance for each of the six proposals outlined in Annex . As the result of additional surveys and as a result of changes to the number of wells, and an investigation into the potential pump-up amounts, the amount of water to be distributed to the conveyance routes was adjusted and an investigation performed for the following two cases.

The investigations incorporated the formation of route proposals for each of the well groups.

1) Canalitos

The pipeline from Teociente to Santa Luisa passes the south of the central part of the Canalitos well group. The route position and route elevation were determined from 1/25,000 scale maps and priority given to the proposal for connection to this pipeline. Conveyance to Juana de Arco was then decided upon from the viewpoint of the relationship between the amount of distribution water and the gravity conveyance method. Moreover, there has also been a significant increase of the population in the area and so the decision was made to provide a tank at San Gasper as part of a future plan of EMPAGUA.

2) Lavarreda

Connection will be made to the existing pipeline network and the water conveyed to Juana de Arco.

3) El Rodio

Connection will be made to the existing Las Ilusiones water distribution pipeline network and pumped to a tank provided on high ground in the area.

The wells adjacent to the Las Ilusiones Treatment Plant will be connected to the existing pipeline network, while a conveyance pipeline will also be provided for a route in a future plan, and a tank will be provided at the end of this pipeline route. (Las Topias)

The 1985 Test Well #3 is to be excavated to a depth of 300m and made into a productive well for connection to the existing pipeline network, while a public standpipe will also be provided to alleviate the present water shortage in this area.

4) Norte

The estimated water demand for Norte in the year 2,000 is 380 l/s. The planned production from the well groups in this

area is 280 l/s and the production of the existing wells and wells to be rehabilitated under the plan are 100 l/s and 148 l/s respectively. In this stage, water will be controled and supplied to the north area (Zone 6) from existing distribution tank, and surplus water will be conveyed to the north-east and central sectors. The direction of conveyance and the amount of water conveyed will differ in yearly plan depends on the production and demand in concerned area. This proposal described in previous paragraph is designed by the demand and supply conditions in 2000.

5) Hermosa

This wellfield includes wells located at the terminus of the Tank Agua Bonita pipeline and wells adjacent to the Plauta El Combray pipeline.

The two wells proximate to Tank Agua Bonita are to be linked, and a tank installed on the higher ground at San Lazaro.

The two wells near the Planta El Cambrey pipeline are to be connected with existing pipeline.

An investigation was therefore performed for the following two cases on the bases of these above premises.

(1) Proposal comparison

a) CASE-A

The Canalitos well group has the largest estimated pump-up volume as well as the largest number of wells and should be able to supply a constant volume of water to the city center.

The number of wells and the pump-up volume for Norte will vary as the direction of conveyance changes in accordance with the yearly plan.

The Lavareda and El Rodio well groups will always be led to Zone 18 while Hermosa will always conduct water in the direction of the city.

Outline of the plan is shown in Fig. 5-2 (1).

A. To City

Canalitos	to Acatan	7P	210 l/s
	New tank of San Gaspar	3P	90 l/s
Hermosa	New tank	2P	60 l/s
	Connection to existing pipes	2P	60 l/s

B. To Zone 18

Canalitos	To J.A	7P	210 l/s
Lavarreda	To J.A	2P	70 l/s
Norte	To J.A	4P	148 l/s
El Rodeo	New tank at Rodeo	2P	40 l/s
	Near by distribution system	1P	20 l/s
	- do -	4P	80 l/s

C. Zone 6

Norte		4P	140 l/s

b) CASE B

The directions for conveyance are the same as those for Case A but there is an excess volume of water in the direction of the city and so that pump-up volume of Canalitos and Hermosa that exceeds the estimated yearly plan is sent from the C.C. distribution reservoir to J.A. in order to maintain the planned conveyance volumes.

The number of wells dug for each well group is the same but the conveyance volume differs along with the numbers of wells dug each year.

(2) Investigation into Conveyance Direction

a) Case-A

Conveyance direction	1990		1995		2000	
	l/s	m^3/s	l/s	m^3/s	l/s	m^3/s
To City	A 210 N 175 L 70	0.46	A 210 G 90 N 40 H 120	0.46	A 20 G 90 H 120	0.23
Zona 18	C 210 R 140	0.350	C 210 L 70 N 150 R 140	0.57	C 210 (J.A) L 70 N 150 R 140 A 190	0.76
Norte			N 90	0.09	N 130	0.13
Total		0.810		1.120		1.120

Note 1: Symbols in the above table are as follows.

A:	Acatan	H:	Hermosa
G:	San Gasper	L:	Lavarreda
N:	Norte	R:	El Rodio
C:	Canalitos	CC:	Tank C.C
E:	Existing line		

Note 2: Figures in parenthesis are the water supply volume for the existing line.

b) Case-B

Conveyance direction	1990		1995		2000	
	l/s	m^3/s	l/s	m^3/s	l/s	m^3/s
To City	A 270(100) G 90 N 110	0.47 (0.50)	A 210(100) G 90 N 20 H 120	0.44	A 0 G 90 H 120	0.21
Zona 18	C 60 L 70 N 15 R 140	0.285	C 150 L 70 R 140 N 170 A 60	0.590	A 270(100) C 150 L 70 N 150 R 140	0.78
Norte E (300)	N 0 (0.30)		E (300) 40 0.04	0.09	E (300) 80 0.13	0.13
Total		0.755		1.120		1.120

5.5 Comparison of Well Conveyance Directions

An investigation into both cases shows the following.

(1) The conveyance route from the well groups is the same for both cases.

(2) The pipe diameter for the conveyance route is in accordance with the maximum water-carrying capacity.

(3) The number of wells to be dug each year changes with the yearly allocation.

(4) Utilization of the existing pipeline network is incorporated.

(5) An auxiliary tank (San Gasper) is to be constructed at Canalitos.

(6) Hermosa uses the El Cambray pipeline network but an auxiliary tank is to be provided for the Tank Agua Bonita pipeline system.

(7) There is some interference because of valleys, and reverse syphons are installed on the river beds at the lower parts. Alternatively, aqueducts can be used.

Comparison of construction cost shows case A is more acceptable for the project as follows:

Unit: Q

Item	Case A	Case B
Water Production System	10,657,166	10,599,466
Water Supply System	5,778,295	5,954,926
	16,435,461	16,545,392

A detailed flow chart of transmission pipeline is shown in Fig. 5-3.

5.6 Booster Pumps

In principle, the design of the conveyance route for the well groups is to be performed for gravity conveyance. However, there will be places for the installation of booster pumps due to the relationship between the direction of conveyance, the topography and differences in the elevation.

The installation of booster pumps for the well groups is as shown in the following diagram.

Booster Pumps for the Well Group

Well Field Name	Location	Diameter	Power (kW)	Unit	Capacity & Head
Canalitos	BP-b	200	75	2	60 l/s x 78m
Norte	BP-2	200	75	2	70 l/s x 70m
	BP-5	125	45	2	35 l/s x 67m
	BP-6	150	45	2	35 l/s x 81m
	BP-T	200	75	3	73 l/s x 70m
Lavarreda	BP-1	125	45	2	35 l/s x 68m
El Rodeo	-	-	-	-	-
Hermosa	-	-	-	-	-
Total	-	-	-	13	-

Note: The total number of units includes the number of spare pumps.

The pumping stations are provided with the following equipment.

Pump units:
main pumps, electric motors (60Hz/460V)

Auxiliary equipment:
check valves, electric-driven, sluice valves, flow meters, manual sluice valves, piping within pumping station, water intake devices, intake pit, inlet valves, facilities to prevent water hammering, control panel, electrical wiring within pumping station, crane and rails

It is normal practise for spare generators to be installed for booster pumps but this will not be performed in this case, given the urgent nature of the project.

5.7 Electrical Facilities

(1) Receiving Plan

Electrical receiving is performed from the EMPRESA power transmission line (13.2 kV) upon consultations with the EMPRESA Electric Corporation. Other areas for which receiving consultations are not yet complete, will receive power from existing lines, and general features detailed is in following TABLES.

Electric Demand

Area group	Recieving place	Submersible pump (number)	Booster pump (place)	Demand (kW)
Canalitos (J.A)	Canalitos	7	1	1,242
- do - (S.L)	Santa Luisa	7	-	1,114
- do - (S.G)	- do -	3	-	449
Norte (T-4.4)	Tank 4.4 Existing lines	6	2	939
- do - (C.C.)	Tank 4.4	2	2	767
Lavarreda (J.A)	Juana de Arco	2	1	362
Hermosa (T-H)	Existing lines	4	-	634
El Rodeo (T-R)	Existing lines	3	-	339
- do - (L.I)	Las Ilusiones	4	-	414
Total		38	6	6,260

(2) Transmission and transformer facilities

The electric load for the well operation is to be Pattern A, with the parallel operation of well and booster pumps being Pattern B. The system of operation is described in FIG. 5-4. The system flow is as follows.

Existing 13.2 kV Transmission Line Pole air switch Tranformer Bay (Outdoor Type) 13.2 kV/460 kV Molded case circuit breakers Submersible deep well pumps.

The transmission and transformer capacities and the pumping electricity demands are described in TABLE 5-3.

Supply electricity lines and transmissions facilities

Area group	Recieving place	Length of lines (m)	Transmissions	
			Place	Capacity (KVA)
Canalitos (J.A)	Canalitos	2,900	7	2,800
- do - (S.L)	Santa Luisa	5,350	7	2,400
- do - (S.G)	- do -	3,400	3	1,000
Norte (T-4.4)	Tank 4.4 Existing lines	3,005	9	4,500
- do - (C.C)	Tank 4.4		2	900
Lavarreda (J.A)	Juana de Arco	610	2	900
Hermosa (T-H)	Existing lines	4,600	4	1,400
El Rodeo (T-R)	Existing lines	2,120	3	600
- do - (L.I)	Las Ilusiones	790	4	1,200
Total		21,290	38	15,700

(3) Electricity Supply Facilities

The supply electricity facilities are as follows.

- Transmission cabinet
- Control device
- Protector
- Shutter
- Make-break devices, contactors
- Transformer
- Lighting rod
- Ammeter
- Ammeter switch
- Accessory facilities
- Electric lines

5.8 Outlet Tanks

Outlet tanks are installed along the conveyance routes at places where the water is lifted to a considerable height by booster pumps.

Outlet tanks are of reinforced concrete construction, with a waterproof coating on the inside. The capacity of the tanks is to be 30 minutes of the pump-up volume of the wells, and the water tank part is to have a depth of approximately one meter.

The places where outlet tanks are provided are shown in the following table.

Outlet Tank

Names	158m^3 (87.5 l/s)		126m^3 (70 l/s)		108m^3 (60 l/s)		63m^3 (35 l/s)	
	Nos	Shape	Nos	Shape	Nos	Shape	Nos	Shape
Canalitos	-		-		-	7.5x7.2m	-	
Norte	1	7.5x10.5m	1	7.5x8.4m	-		2	7.5x4.2m 5x6.3m
Lavarreda	-		-		-		1	5x6.3m
Total	1		1		1		3	

5.9 Water Tanks

The water pumped up from the well groups passes along the conveyance routes which are connected to the existing pipes and tanks of EMPAGUA. However, the new conveyance route that is to be constructed, is to have water tanks provided at the terminals of the pipe system.

The structure of these water tankses to be of reinforced concrete, and the shape is to be square. The internal surface of the water tanks is to be given a waterproof coating and water level gauges are to be fitted.

The capacity of the tanks is to be seven hours capacity of all of the connected wells. However, EMPAGUA has formed a water distribution plan for the El Rodio and Las Tapias blocks and the tanks tentatively planned for until the works are finished are to have a capacity of two hours. Furthermore, the Test Well #2 in the El Rodio block is to be provided with a water tank for joint utilization.

The following table shows the positions for the installation of the water tanks.

Water Distribution Tank

Wellfield Name	Tank Name	Capacity	Nos.	Notes
Canalitos	San Gasper	2,835m^3	1	
El Rodeo	El Rodeo	1,260	2	On hilltop
"	Test Well No. 3	25.2	1	Water Valve for joint use
"				
Hermosa	Hermosa	1,890	1	
Total			5	

The existing tanks of EMPAGUA that relate to this plan are shown in following table.

Specifications of Existing Tanks

Name	Type	Capacity	Shape	Note
Acatan No. 1		30,430	77.3 x 642 x 6.13	
" No. 2		11.380	51.7 x 39.5 x 5.6	
El Cambray	Bajo	3,300	37.5 x 21 x 4.2	
"	Circular	2,820	R = 12.45 x 5.8	
Agua Bonita		565	129.1m^2 x 4.4	
"		330	137.8m^2 x 4	
TP - 3		3,515	R = 12.5 x 7.16	
Las Ilusiones	Bajo	4,150	36 x 30 x 3.85	
"	Elevado	190	R = 3.0 x 6.44	
Juana de Arco		5,400	30 x 30 x 6	
"	Circular	200	R = 5.0 x 2.6	

5.10 Purification Method

The project is one to raise aquifer groundwater and so it is thought that there will be the following problems regarding the quality of the water.

(1) There are many methods available for the processing of groundwater but only the chlorination method will be used when the water quality of the raw water is as described in the following.

Quality of raw water

1) Coliform bacteria (100 ml MPN) 50 max.
2) General bacteria (1 ml) 500 max.
3) Other items are to be in conformity with water quality standards

Results of tests for water taken from test wells

According to the results of tests for water sampled during the 1986 test wells, there was a considerable degree of scattering. Looking at the case for Test Well #2 for which the results of the water sampling tests were good, there were high values shown for the turbidity, general bacteria and also for coliform bacteria. These values are thought to be due to the intrusion of sewage from nearby residences along the road in the southern part, and due to the houses being adjacent to the boring itself. There is also a component thought due to mud (used as a bulwark) in the course of excavation.

Because of this, the water is judged to be suitable for drinking if chlorination is performed and the inflow of water from the road is provented.

Treatment method

Chlorination will be used as the method of treatment.

(2) The following three methods will be used in combination for the introduction of chlorine according to the well group and the coveyance method.

1) Installation at each well
2) Installation for a group of wells
3) Processing at existing water treatment plants

(3) Introduction Facilities

The method of chlorine introduction will be by vacuum introduction equipment using injector. This equipment will be directly connected to 50 kg cylinders with main valves, and will have safety valves, devices to prevent over-vacuum, and the necessary instrumentation.

(4) Locations for Installation

1) Canalitos
   a) Water will be conducted to the Santa Luisa purification plant and so the existing facilities will be used (No. of wells: 7)
   b) Installed at the Canalitos pumping station (No. of wells: 7)
   c) Installed at San Gasper new tank (No. of wells: 3)

2) Norte
   a) Existing facilities at Tank 4-4 are used (No. of wells: 6)
   b) Installed for each Well (No. of wells: 2)

3) Lavarreda
   a) Installed for each well (No. of wells: 2)

4) El Rodeo
   a) Installed at new Rodeo Tank (No. of wells: 2)
   b) Installed for each Well (No. of wells: 3)

5) Hermosa
   a) Installed for each well in the Agua Bonita system (No. of wells: 2)
   b) Installed at Well No. 3 and 4 (No. of wells: 2)

Total: 11 locations; 38 wells

(5) Initial Supply to Existing Facilities

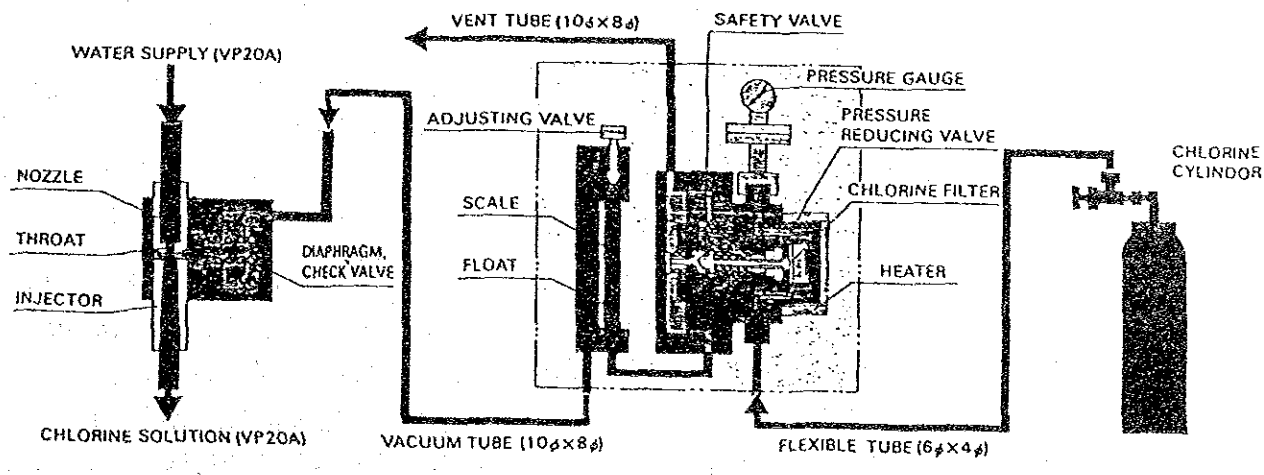
Existing Facility	Initial Supply	Water Source
Santa Luisa	2.2 mg/l	dam
Las Ilusiones	2.7	low dam
El Cambray	2.7	river spring
La Brigada	4.6	river spring
Lo de Coy	3.4	river
Ojo de Agua	1.7	groundwater

Initial Supply is determined as 2.2 mg/l on the average supply of Santa Luisa, has Ilusiones and Ojo de Agua.

(6) Liquid Chemical Treatment

Chlorinators (for chlorination at wells) is drown as follows.

Chlorinator



5.11 Operation and Maintenance

5.11.1 Determining the O/M Offices

The present management offices of EMPAGUA include the following five types organized beneath the production department of the O/M section.

Well and pump management offices
Las Ilusiones management office
Ojo de Agua management office
Santa Luisa
Lo de Coy management office

The O/M section also contains an environment department, an electrical facility maintenance department, a cost management office, a water quality management office and a water distribution department.

The water supply system consists of Lo de Coy, Ojo de Agua, Santa Luisa, Las Ilusiones, El Cambray, La Brigada and the wells in the city.

Three proposals can be considered under the management with this project. They are the new construction of O/M offices for the wells, the use of existing O/M offices for both the new wells as well as the existing wells, and then reorganization of the existing management offices of EMPAGUA's O/M section.

(1) Case for New Well Groups Only

The main points become Acatan, Juana de Arco, Zone 6,4-4 and Finca El Rodeo (Zone 18) when the conveyance routes and the terminal points (Connections with existing networks) of the new wells are considered.

It is therefore desirable that O/M offices be located close to these points. If this is selected, then the locations would become (a) Santa Luisa (Acatan) and Las Ilusiones (Juana de Arco, Finca El Rodeo), zona 6 (4-4), or (b) included within the two existing water purification facilities at Santa Luisia and Las Ilusiones.

(2) In the case of O/M combined with that for existing facilities for the performance of O/M in the same way as is now being performed, then it is necessary for EMPAGUA to perform an investigation into wells that either have a low pump-up volume, and those that are to be decommissioned due to earthquake damage, and for the O/M proposal for this project to be drawn up for the remaining wells and the new well groups.

In this case, there would be 44 existing wells that remain, while the 38 new wells would bring the total to 82.

Existing & New Wells

Well Group	Existing Well	New Well	Total
CIUDAD	17 wells	4 wells	21
OJO DE AGUA	9	-	9
Zone 6	7	8	15
BRIGADA	5	-	5
LAS ILUSIONES	3	17	20
SANTA LUISA	1	9	10
HINCHPIE	1	-	1
BELEM	1	-	1
Total	44	38	82

(3) Reorganization of the Management Section within the Present EMPAGUA Organization

a) Proposal for O/M under the existing system (with extra well and pump management offices provided)

b) Reorganization of the system on the basis of the number of wells in the region.

On the basis of the three proposals described above, the new and old well groups are spread over a wide region but the sub-stations are provided for groups of relatively close wells, with there being about seven wells per substation. However, that for Hincapie will remain as it is since it lies at such a distance.

The position of the wells becomes fairly remote in the case of these substations and so site offices will have to be constructed at the pumping stations and resident staff maintained. O/M offices for new wells can be divided into those for which the direction of conveyance is the city, the northeast and the north.

When considering only the well groups, the number of wells doubles to 82 and so it is proposed that the management offices be reorganized if the increase is too great. In other words, either reinforcement or reconstruction of the offices at Santa Luisa (10 wells), Pozo and Bomba (21 wells), Las Ilusiones (20 wells) and Zone 6 (15 wells) is proposed.

With the exception of Zone 6, other management offices already have land and buildings available. The construction expenses for this plan will therefore not be great.

The system for O/M commands and instructions is O/M section - production department - management office - O/M office - Main Station—sub-station - each pump station.

(4) Final Proposal

The final proposal is for O/M offices to be provided in conjunction with the Las Ilusiones and Santa Luisa purification facilities that form part of the existing water supply system.

Main stations are to be installed at 5 points on the water conveyance system with existing facilities, and sub-stations are at 7 locations including 4 new-construction as follows.

O/M Office	Main Station	Sub-Station
Santa Luisa	Cerro de Arco	Tank 4-4
Las Ilusiones	Juana de Arco	Juana de Arco
	Las Ilusiones	Las Ilusiones
	Santa Luisa	El Rodeo
		North Canalitos
		Sorth Canalitos
		San Gasper
		Hermosa

Huts are to be built for the persons in charge of the new wells.

The O/M commands and instructions are received by telephone from the production department of the O/M section and relayed to the two O/M offices, and UHF transceivers are used to relay them from the O/M management offices to the sub-stations. UHF transceivers are used to instruct the mobile stations covering around five wells each. Communications, inspection and maintenance between wells is carried out by the vehicles associated with each.

Phisical Features of O/M Offices

1) O/M Offices

a) Santa-Luisa
b) Las Iluciones

Both offices will be incorporated within existing treatment plant structures thereby eliminating need for new construction.

2) Main Stations

A main station will be established for each of the four conveyance pipeline systems. Main statins will be housed in existing structures.

a) Cerro de Carmen
b) Juana de Arco
c) Las Ilusiones
d) Santa Luisa

3) Sub-station

Sub-stations will be located at the following 7 locations:

a) Tank 4-4 (to use existing structure)
b) Juana de Arco (to use exisitng structure)
c) Las Ilusines (to use existing structure)
d) El Rodeo (to be newly constructed)
e) North Canalitos (to use existing structure)
f) South Canalitos (to be newly constructed)
g) Hermosa (to be newly constructed)

Either extension or new construction work in steel-frame and concrete block is to be performed to form buidlings of 120 m^2 in area and covering a site area of approximately 40 m^2.

4) Pump Stations

The buildings for the pump station are to be reinforced concrete block structures 13m^2 in area and on sites of 100m^2. They are to serve the new wells.

5.11.2 Pump Operation

Pump operation can be either (1) the remote control method, (2) the semi-remote control method or (3) the individual control method.

Method (2) was selected upon consideration by following reasons.

a) Production wells are located in block-wise
b) O&M cost have to be saved
c) Effective control system is required

5.11.3 O/M Road

Existing roads are to be used to the greatest extent possible as operation and maintenance roads, so as to reduce the amount of new road construction. O/M road under the jurisdiction of the main station is as follows.

(1) The Santa Luisa system has Tank Acatan, Tank San Gaspar (newly constructed) and the new well groups forming the object of management and maintenance, with existing roads being used for the newly constructed wells. O/M is to be performed for 14 wells.

(2) The Las Illusiones system includes National Highway CA-9, national highway route 15, the roads inside Zone 18 and the Finca Las Conohas road, and patrol of both the existing and the new facilities is possible using these roads only. O/M is performed for 24 wells.

Nevertheless, some construction of new roads will be unavoidable in both systems because of the particular circumstances of the individual facilities (mainly to do with the syphons).

(3) For Hermosa, the existing roads such as National Highway No. 1 can be used for practically all purposes.

(4) Well groups for maintenance and inspection (draft)

Inspection and management for the new wells is performed by the O/M office sub-stations in the following manner.

Existing roads can be used for the O/M described above but there are some roads that will have to be repaired and also some that will have to be newly constructed. These are listed in the following table.

Operation and maintenance Road

Substation	Existing roads used (m)	Roads requiring repair (m)	Newly constructed roads (m)	Total (m)
Canalitos (J.A-Line)	9,110	1,450	-	10,560
(S.L-Line)	5,960	-	250	6,210
(San Gasper)	3,500	-	50	3,550
Norte	16,070	-	1,120	17,190
Lavarreda	4,360	-	100	4,460
El Rodeo	11,020	-	1,260	12,280
(Hermosa)	2,800	-	400	3,200
Total	52,820	1,450	3,180	52,450

The relationship between these roads and the well groups is indicated in FIG. 5-5-(1)-(4). The structure of the roads that are either to be repaired or newly constructed is such that three is a total width of 5 meters and drainage to one side. These roads are provided as temporary roads and paved with gravel. A vehicle bay is provided for every 400 meters of length.

Those management roads for which the existing national highways and roads can be used, were excluded from being included in the object of road management and maintenance.

5.11.4 Workshop

Workshop is very important facter for O&M managing, and detail recommendation is mentioned Appendix VI supplementary study.

(1) Site for Construction

Construction is to be made on land having EMPAGUA facilities.

The present maintenance sheds that are owned by EMPAGUA include (1) Unidad Ejecutora in Zone 2, (2) the vehicle maintenance shed (on a small site in Zone 4) and (3) the La Brigada purification plant. As far as their functions as workshops is concerned, these locations are close to the pump facilities and are conveniently located for travel.

(2) Building Area

The building area is to be about 250m^2 with the buildings themselves being of concrete block construction with overhead cranes are installed below the roof.

If concentrated maintenance is performed for all of the EMPAGUA wells, then it will become necessary to provide a storeroom-warehouse as a separate construction.

(3) Facilities

The present workshop has insufficient facilities and equipment to perform adequate maintenance and there is also as insufficient stock of spare parts. The following facilities are necessary in order to perform maintenance of the well equipment as well as repair of the equipment parts.

a) General Facilities

Crane, steam cleaner, small engine block, hydraulic press, air compressor, parts cleaning tank, etc.

b) Processing facilities

Lathe, electric drill, bench lathe, bench grinder, portable sander, spraygun, arc-welding equipment, oxy-welding equipment, general tools, sheet metal tools, casting tools, etc.

c) Electircal facilities

Battery liquid guage, voltmeter/ammeter, recharger, excel tester, regulator

d) Vehicles, walkie-talkies, telephones

5.11.5 Phisical Features of Water Supply System

Phisical features of required water supply facilities are shown in TABLE 5-3.

TABLE 5-1 Conveyance/Distribution Pipe Types and Features

Material	Advantages	Disadvantages
Cast iron (with mortar lining)	(1) Relatively great strength, durable (2) Relatively easy to connect (3) Mechanical connections can expand and contract for simplifier connection.	(1) Weak against impact (2) Heavy (3) Necessity for anti-pullout connections and/or protectors for assymetrical joints (4) Protection for the exteriors and connectors is necessary when the soil is particularly corrosive.
Ductile cast-iron pipes (with mortar lining)	(1) High strength and corrosion resistant (2) Highly tough and strong against impact (3) Mechanical connectors can expand and contract to facilitate laying (4) Many types of connectors developed for different purposes (5) Connectors of large-diameter pipes can be repaired from the inside	(1) Relatively heavy weight (2) With the exception of special connectors, anti-pullout connectors and/or protection for assymetrical joints is necessary (3) Protection for the exteriors and connectors is necessary when the soil is particularly corrosive.
Steel pipes (with coating) Steel pipes (with coating)	(1) High strength (tensile, bending) (2) Highly tough and strong against impact (3) Monolithic joints are possible through welding and measures against pullout are unnecessary (4) Relatively lightweight (5) Inexpensive	(1) Necessary for expansible connectors with respect to temperature changes and sinking, etc. (2) Countermeasures are necessary for electrical corrosion (3) Connector welding and coating is time-consuming and execution of this work is difficult if there is spring water (4) Large flex in pipes causes problems with the coatings in the case of large diameters

Cont'd

Material	Advantages	Disadvantages
Asbestos pipes	(1) Anti-corrosive and resistant to electrical corrosion (2) Connectors can expand and contract (3) Lightweight and easy to lay (4) No changes in the surface roughness (5) Inexpensive	(1) Small shear strength (2) Necessity for anti-pullout connections and/or protectors for assymetrical joints (4) Easily eroded, depending on the nature of the water and the soil (coating is desirable in these cases)
PVC pipes	(1) Anti-corrosive and resistant to electrical corrosion (2) Lightweight and easy to lay (3) Adhesive connection is possible (4) No changes in the surface roughness (5) Inexpensive	(1) Low strength when compared to metal pipes (2) Impact strength lowers at low temperatures (3) Weak against organic solvents, heat and ultraviolet rays (4) Care required for poisoning and fires due to organic solvents in connection adhesives (5) Flexible connections are required with respect to temperature changes and sinking, etc.
Prestressed concrete pipes	(1) Anti-corrosive and resistant to electrical corrosion (2) Connectors anc expand and contract (3) No changes in the surface roughness (4) Inexpensive	(1) Other types are necessary for abnormally-shaped pipes (2) Steel pipes are necessary for adjuster pipes (3) Heavy

TABLE 5-2 POWER RATINGS FOR SUBMERSIBLE PUMPS AND TRANSFORMER CAPACITIES

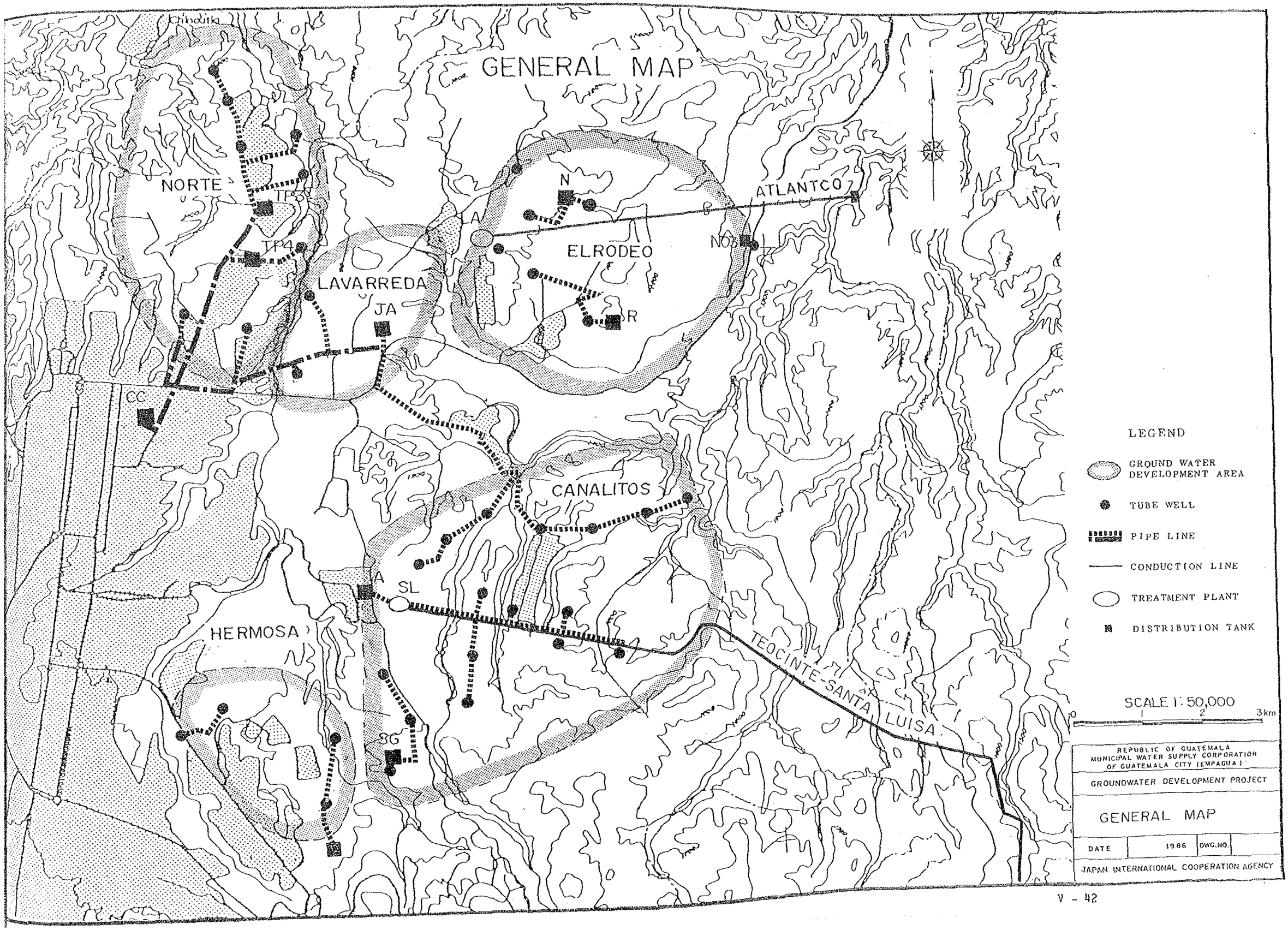
Area Group	Well No.	Sub-mersible Pump	Booster Pump	Transformer Capacity kVA	Drawing Pattren	Field Control	Remarks
Norte	1	185kWx1		400	A	1	
(Tank 4-4)	2	132kWx1	75kWx2	600	B	1	
	3	185kWx1		400	A	1	
	4	185kWx1		400	A	1	
	5	132kWx1	45kWx2	500	B	1	
	7	185kWx1		600	A	1	
	8	185kWx1		400	A	1	
(Tank C-C)	6	132kWx1	45kWx2	500	B	1	
		B.P	110kWx3	700	B	1	
Canalitos	1	132kWx1		300	A	1	
(J.A)	2	185kWx1		400	A	1	
	3	185kWx1		400	A	1	
	7	185kWx1		400	A	1	
	9	185kWx1		400	A	1	
	10	110kWx1		200	A	1	
	11	185kWx1	75kWx2	700	B	1	
(Acatan)	4	110kWx1		200	A	1	
	5	132kWx1		300	A	1	
	6	185kWx1		400	A	1	
	8	185kWx1		400	A	1	
	12	185kWx1		400	A	1	
	13	132kWx1		300	A	1	
	14	185kWx1		400	A	1	
(S.G)	15	185kWx1		400	A	1	
	16	132kWx1		300	A	1	
	17	132kWx1		300	A	1	
Lavarreda	1	132kWx1	45kWx2	500	B	1	
(Tank J.A)	2	185kWx1		400	A	1	
Hermosa	1	132kWx1		300	A	1	
	2	185kWx1		400	A	1	
	3	185kWx1		400	A	1	
	4	132kWx1		300	A	1	
El Rodeo	1	132kWx1		300	A	1	
	2	132kWx1		300	A	1	
	3	75kWx1		200	A	1	
	4	75kWx1		200	A	1	
	5	132kWx1		300	A	1	
	6	75kW		200	A	1	
	7	132kWx1		300	A	1	

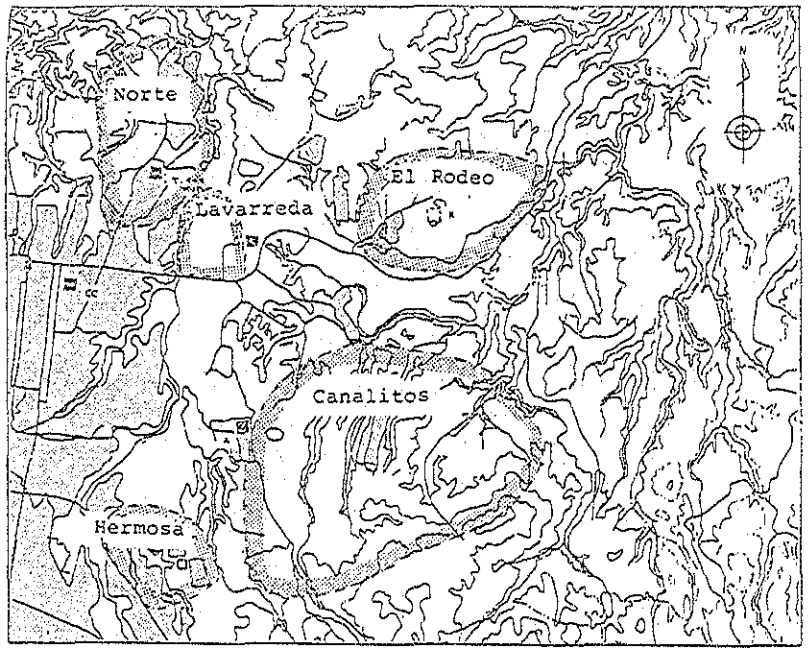
TABLE 5-3 (1)

PROJECT FACILITIES

Item	Canalitos: Juna de Arco	Canalitos: Santa Luisa	Canalitos: San Gaspar	Norte	Lavarreda	El Rodeo	Hermosa	Coment
1. Production Facilities								
(1) Tube Well	7nos x 30ℓ/s	7nos x 30ℓ/s	3nos x 30ℓ/s	8nos x 35ℓ/s	2nos x 35ℓ/s	7nos x 20ℓ/s	4nos x 30ℓ/s	Total 1,120ℓ/s (1,000ℓ/s under 90% of operation efficiency)
(2) Casing	ø300 300m	ø300 300-350m	ø300 300-350m	ø300 300m	ø300 300m	ø300 300-350m	ø300 300m	
(3) Strainer	30m, 40m	30m	30m	30m, 40m	30m	30m	30m	
(4) Submerged Pump	1nos x 110kW 1nos x 132kW 5nos x 185kW	1nos x 110kW 2nos x 132kW 4nos x 185kW	2nos x 132kW 1nos x 185kW	3nos x 132kW 5nos x 185kW	1nos x 132kW 1nos x 185kW	3nos x 75kW 4nos x 132kW	7nos x 132kW 2nos x 185kW	
2. Water Transmission Facilities								
(1) Ductile Cast Iron Pipe								
ø150mm	-	-	-	-	-	2,830m	-	Total 2,830m
ø200mm	1,770m	3,450m	950m	4,650m	1,400m	390m	2,300m	14,910m
ø250mm	2,360m	250m	1,000m	780m	-	-	900m	5,290m
ø300mm	1,450m	1,360m	-	200m	-	-	-	3,010m
ø350mm	1,080m	-	-	360m	-	-	-	1,440m
ø400mm	-	-	-	500m	-	-	-	500m
ø450mm	3,900m	-	-	300m	-	-	-	4,200m
ø500mm	-	2,000m	-	-	-	-	-	2,000m (34,180m)
(2) Discharge Tank	108m^3			2nos x 63m^3 126m^3 158m^3	63m^3			
(3) Booster Pump	1nos x 60ℓ/s			2nos x 35 ℓ/s 1nos x 70 ℓ/s 1nos x 87.5ℓ/s	1nos x 35ℓ/s			
(4) Syphon Bridge	2nos x (L=20m)						1nos x (L=20m)	
(5) Distribution Tank			2,835m^3			2nos x 1,260m^3 25.2m^3	1,890m^3	
3. Power Transmission Facilities								
(1) Electric Line Length	2,900m	5,350m	3,400m	3,005m	610m	2,910m	4,600m	Total 22,775m
(2) Transfarmer Number	7nos	7nos	3nos	9nos	2nos	7nos	4nos	39nos
(3) Access Road		3km						
4. O/M Road								
(1) O/M Road Construction	-	250m	50m	1,120	100m	1,260m	400m	Total 3,180m
Widening	1,450m							1,450m
5. Maintenance Facilities & Equipment								
(1) O/M Station	x Juana de Arco	x Santa Luisa		x Cerro de Carmen		x Las Ilusiones		x : Existing o : Construction
(2) Sub Station	o Juana de Arco	o Santa Luisa	x San Gasper	x T.K. 4-4	x Lavarrede	x Las Ilusiones	o Hermosa	
(3) Transceiver (UHF)	2nos x (Main Transceiver) 15nos x (Handy Transceiver) 2nos x (Battery Charger)							
(4) Work Shop	1nos 250m^2 (New Construction)							

GENERAL MAP


NORTE
TP3
TP4
LAVARREDA
JA
CC
N
LA
ELRODEO
R
ATLANTCO
NO3
CANALITOS
A
SL
HERMOSA
SG
TEOCINTE-SANTA LUISA
LEGEND
GROUND WATER DEVELOPMENT AREA
TUBE WELL
PIPE LINE
CONDUCTION LINE
TREATMENT PLANT
DISTRIBUTION TANK
SCALE 1: 50,000
0 1 2 3km
REPUBLIC OF GUATEMALA
MUNICIPAL WATER SUPPLY CORPORATION OF GUATEMALA CITY (EMPAGUA)
GROUNDWATER DEVELOPMENT PROJECT
GENERAL MAP
DATE 1986 DWG.NO.
JAPAN INTERNATIONAL COOPERATION AGENCY

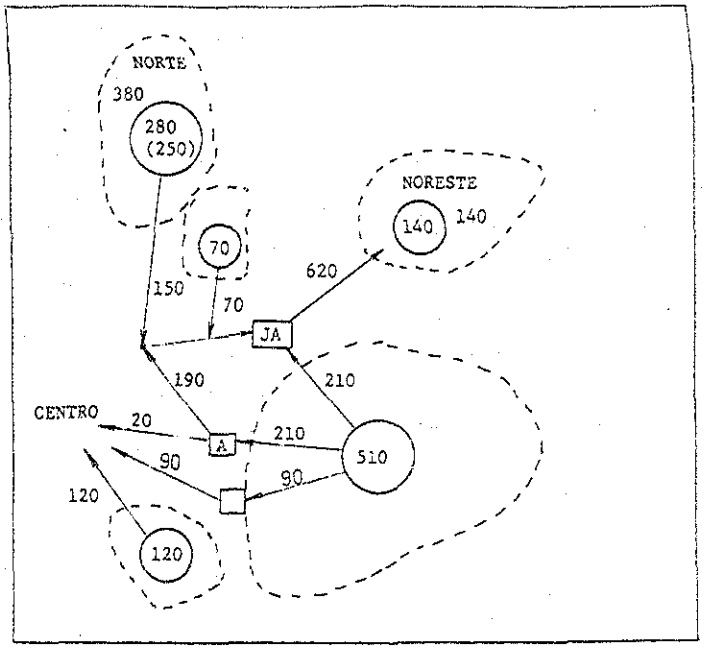


CASE - A

2000

TO BE SUPPLIED BY EMERGENCY I

CENTRO	100
NORTE	140
NORESTE	760



1990

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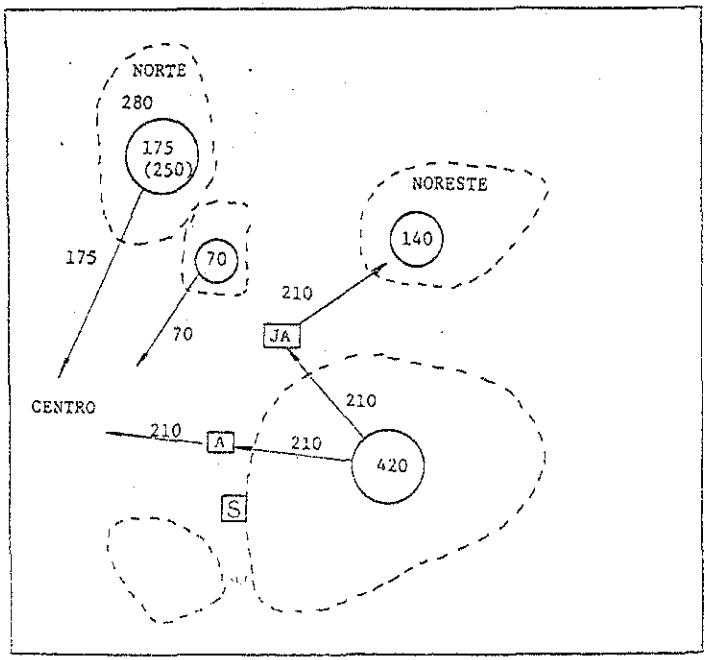
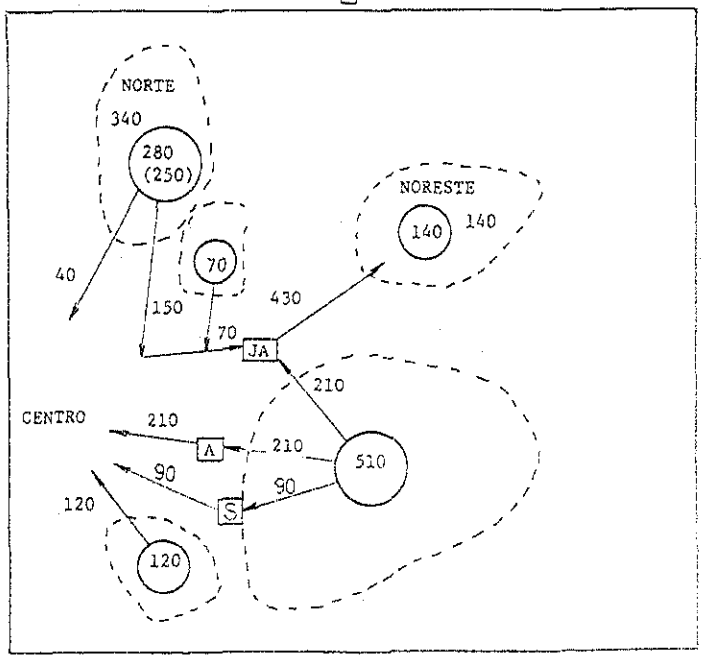
CENTRO	460
NORTE	-
NORESTE	220

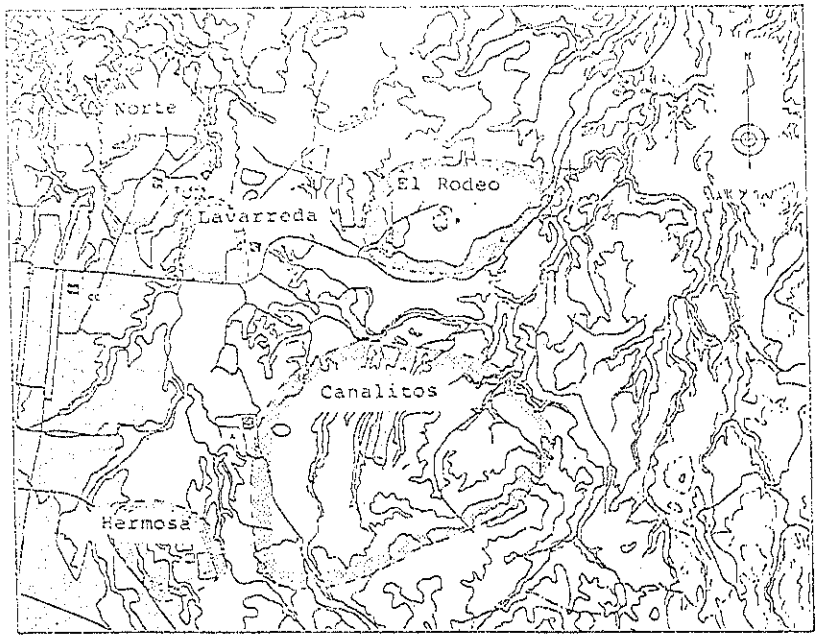


1995

TO BE SUPPLIED BY EMERGENCY I

CENTRO	460
NORTE	100
NORESTE	440





CASE - B

2000

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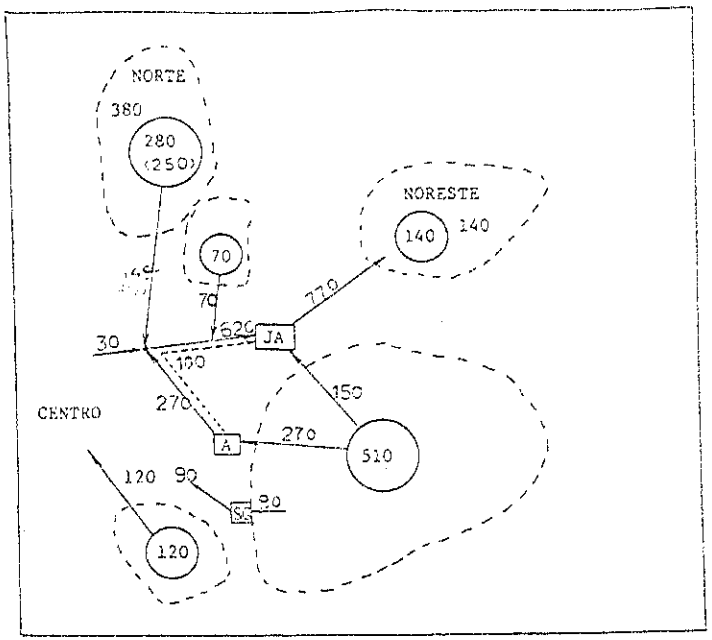
CENTRO	180
NORTE	(380)
NORESTE	740



1990

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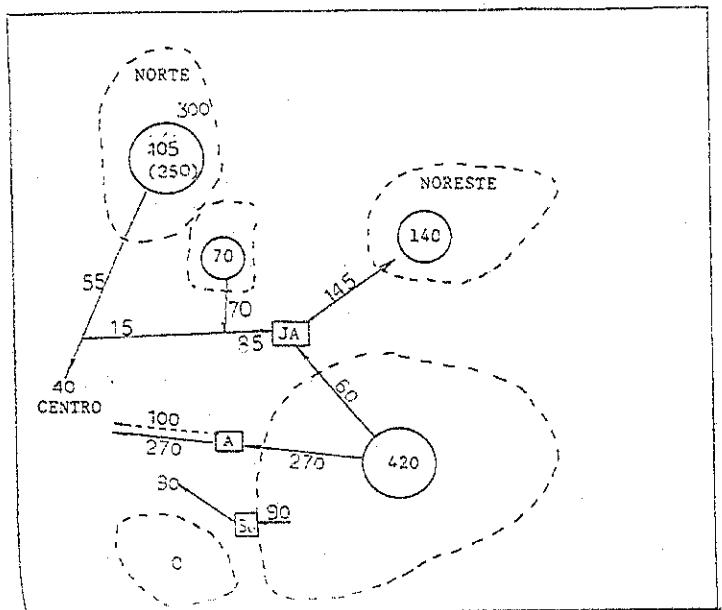
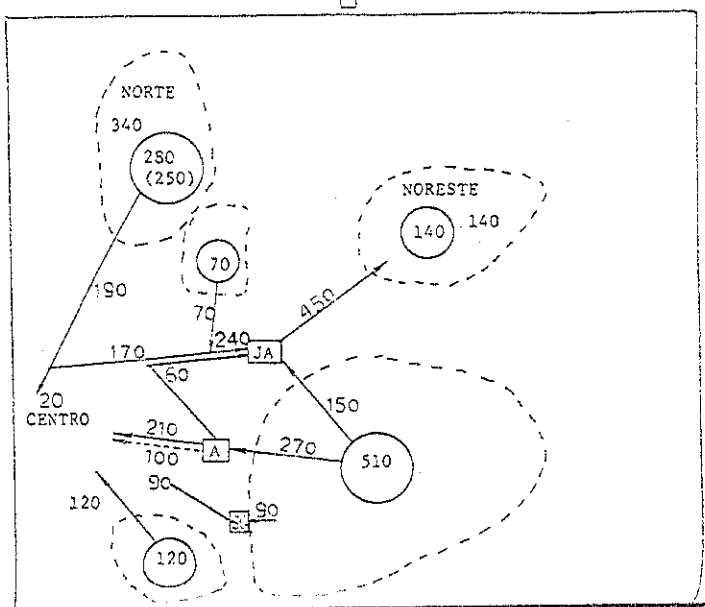
CENTRO	500
NORTE	(300)
NORESTE	200

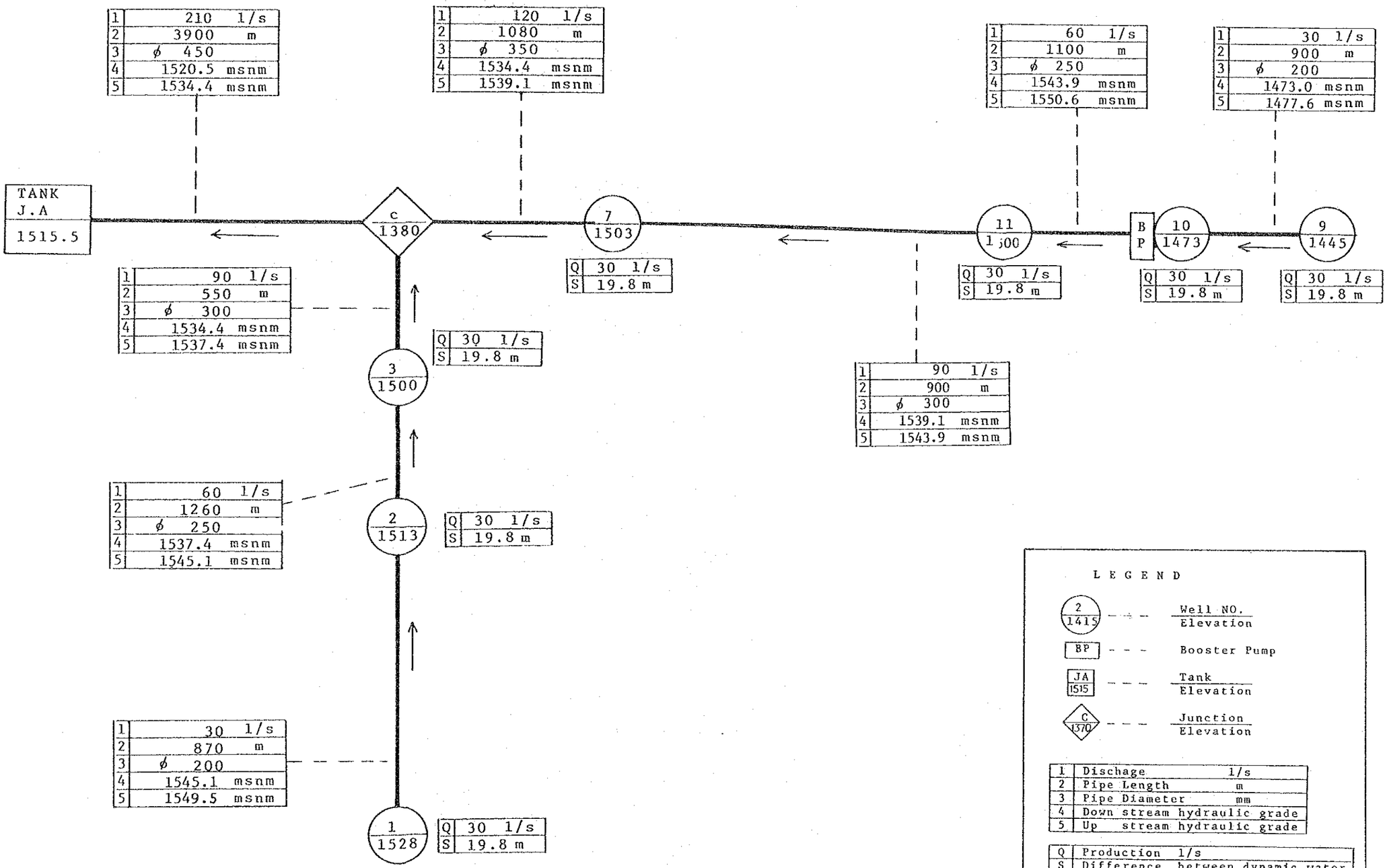


1995

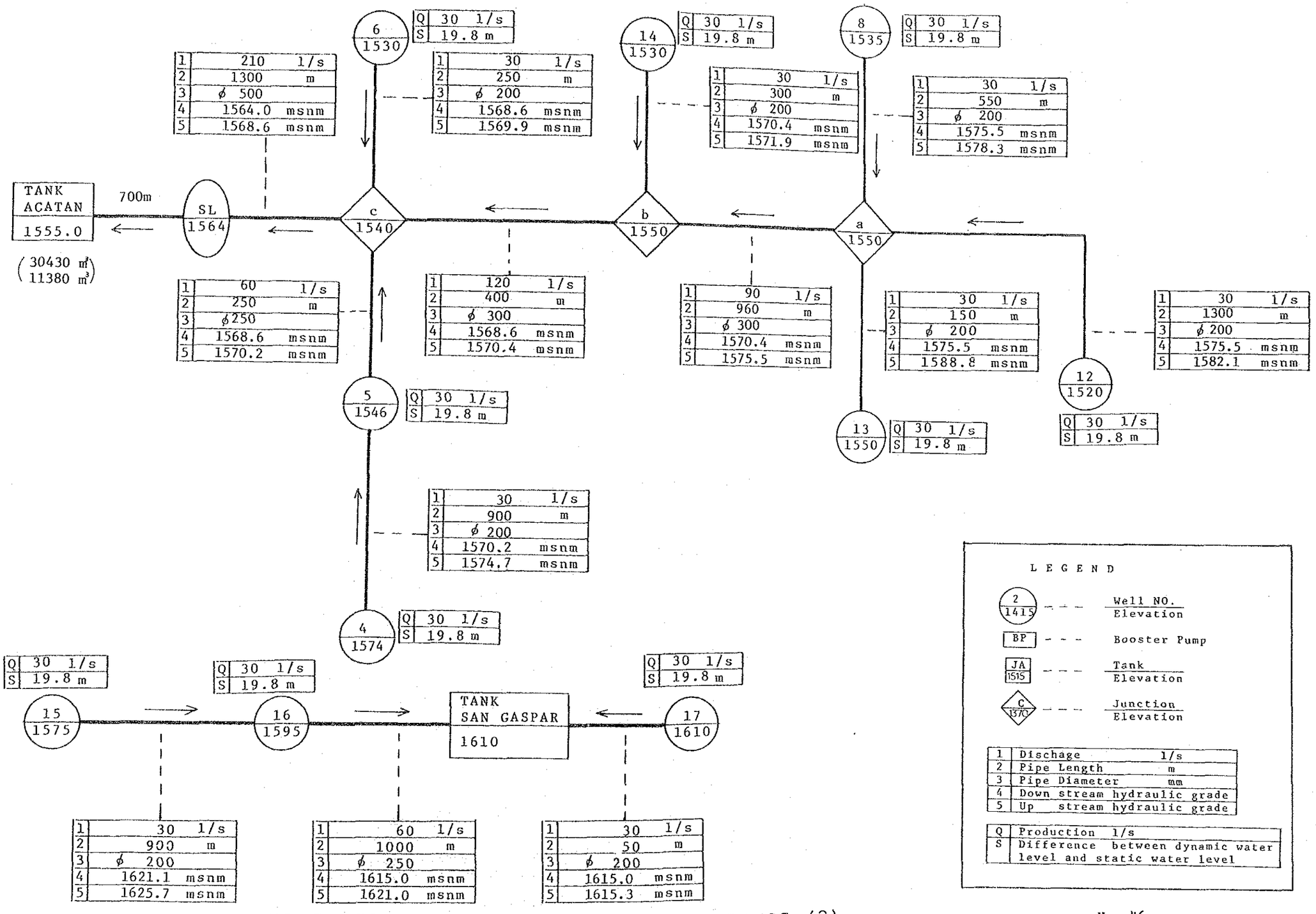
TO BE SUPPLIED BY EMERGENCY I

CENTRO	540
NORTE	(340)
NORESTE	420

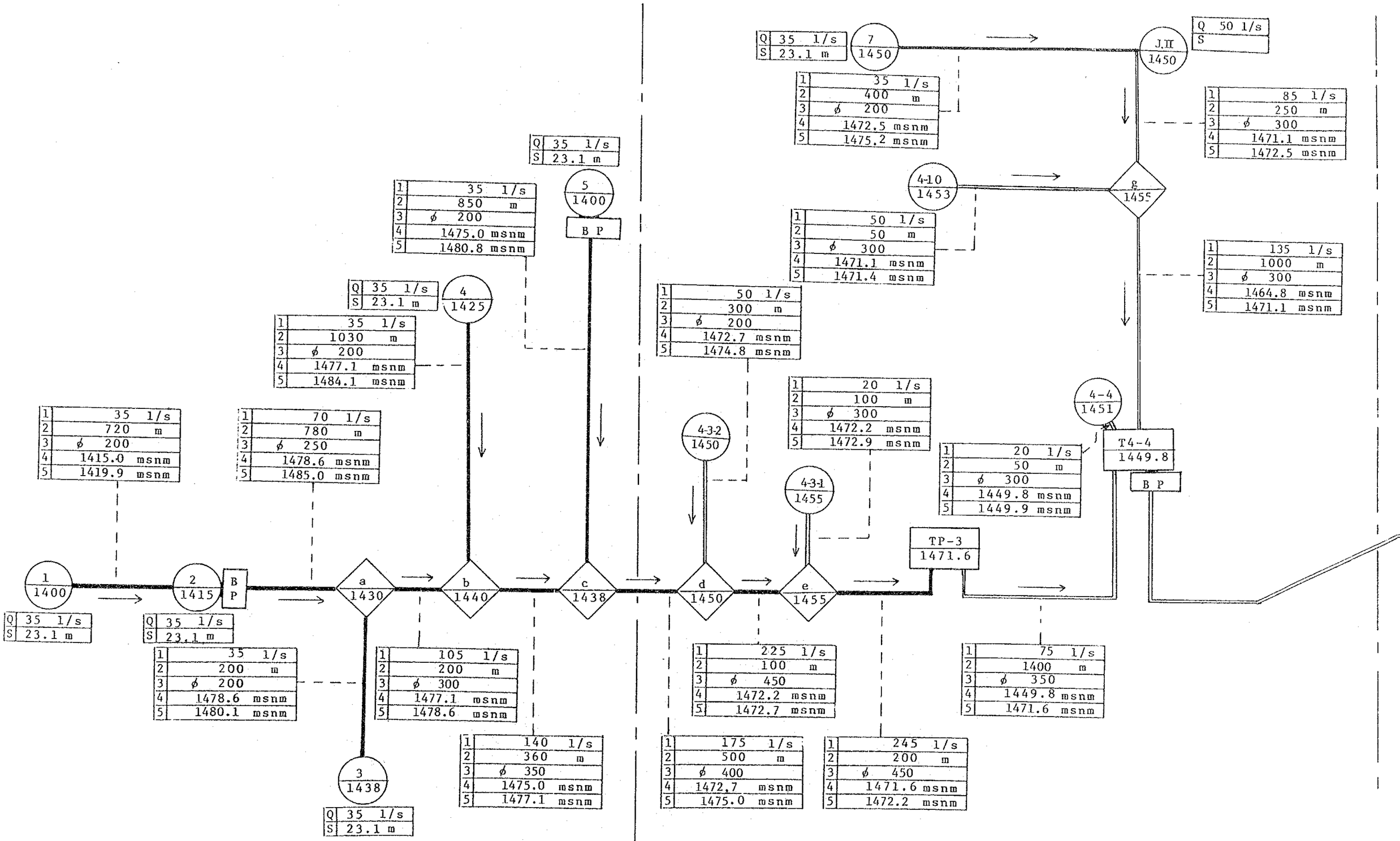




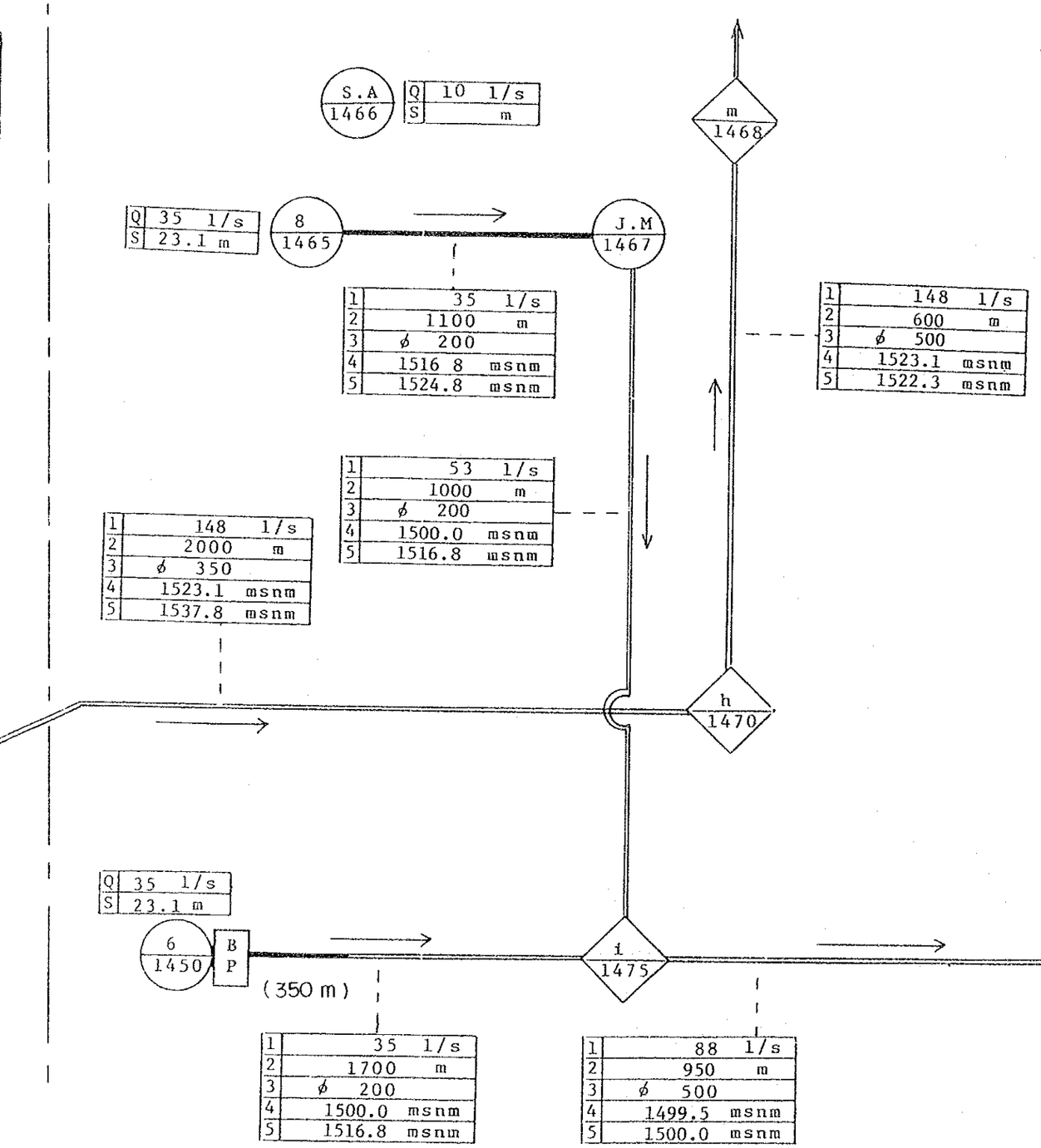
TRANSMISSION LINE SCHEME CANALITOS (1)



TRANSMISSION LINE SCHEME CANALITOS (2)



TRANSMISSION LINE SCHEME NORTE



L E G E N D

2 / 1415 — Well NO. / Elevation

BP — Booster Pump

JA / 1515 — Tank / Elevation

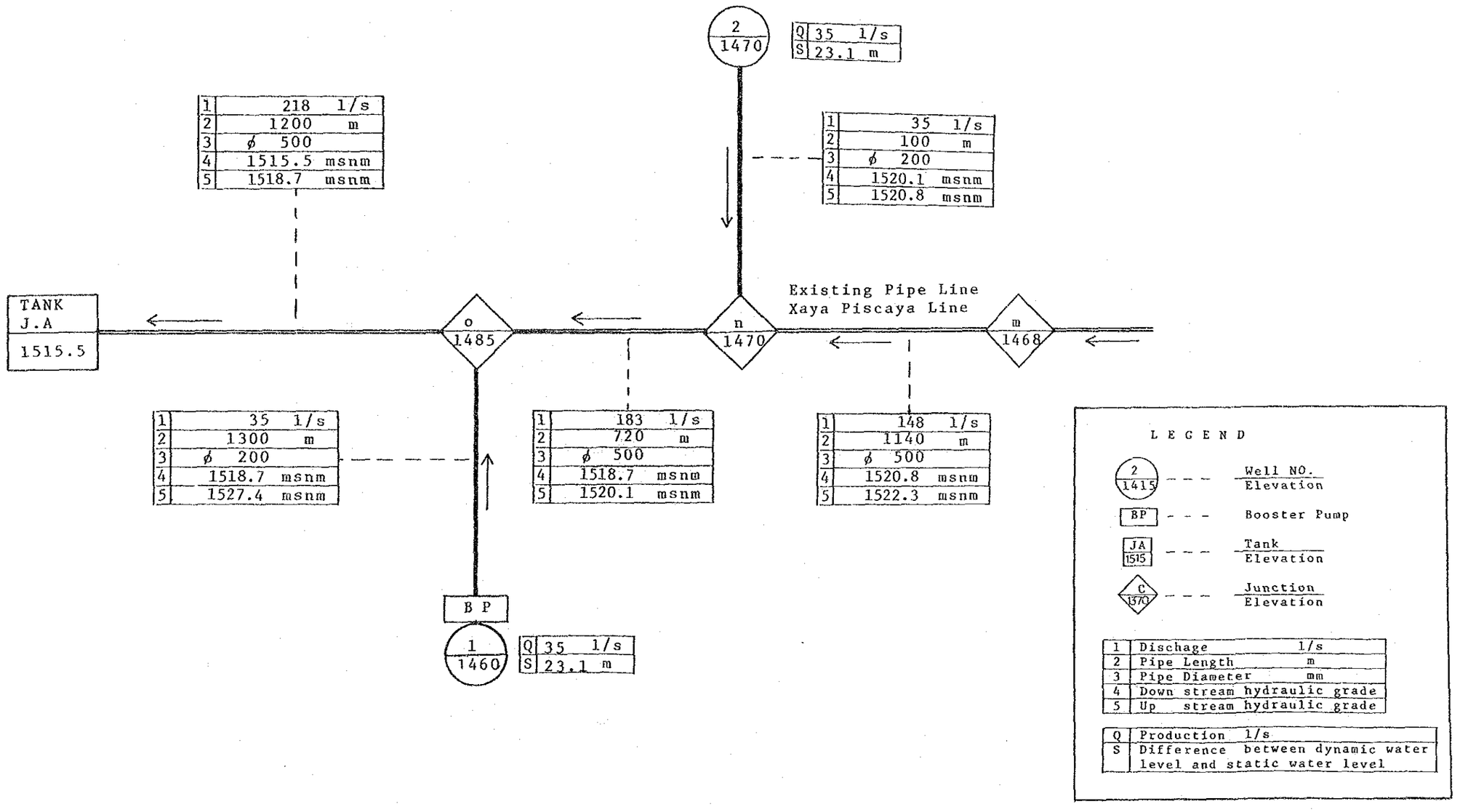
C / 1570 — Junction / Elevation

1	Dischage	l/s
2	Pipe Length	m
3	Pipe Diameter	mm
4	Down stream hydraulic grade	
5	Up stream hydraulic grade	

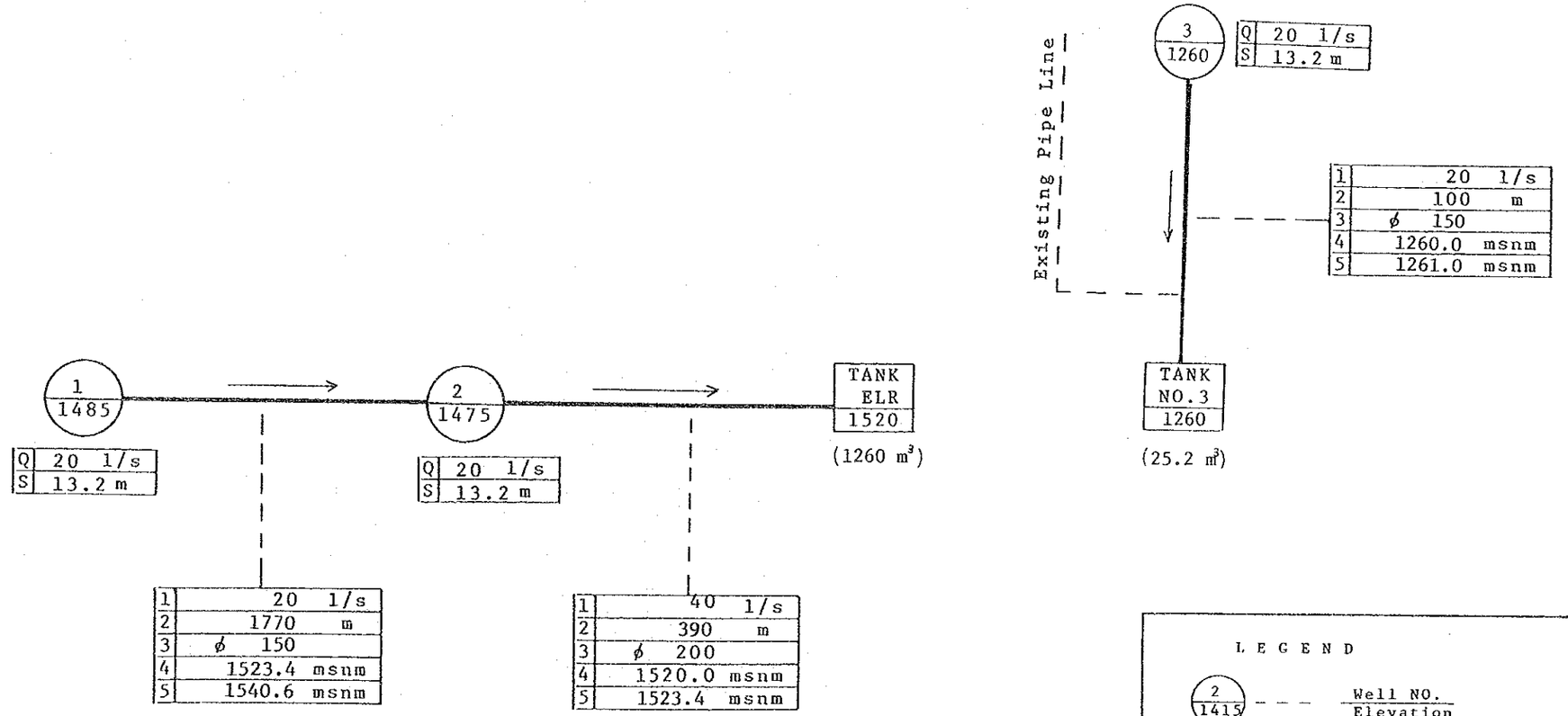
Q	Production l/s
S	Difference between dynamic water level and static water level

Existing Pipe Line

New Pipe Line



TRANSMISSION LINE SCHEME LAVARREDA



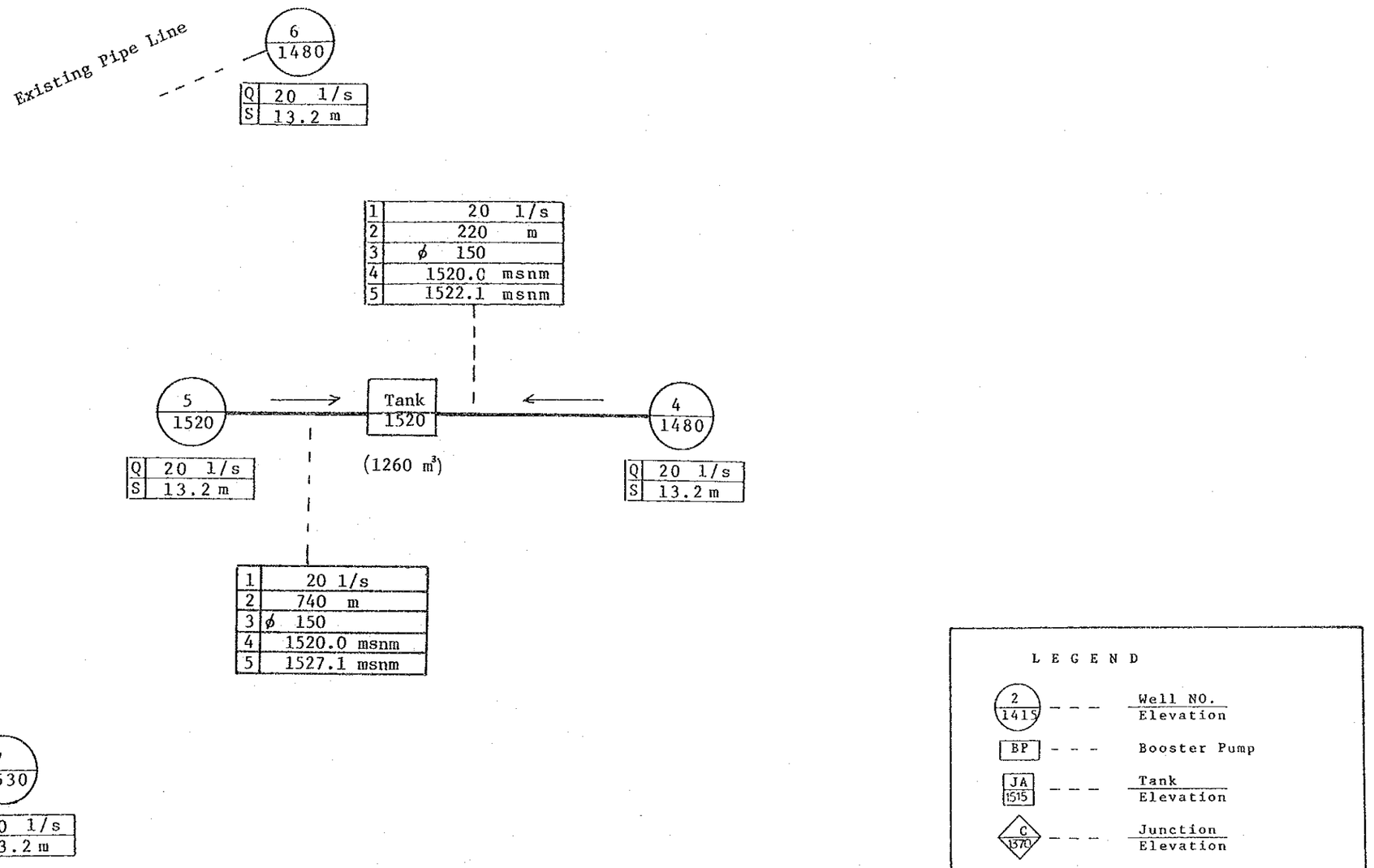
L E G E N D

2 / 1415	Well NO. / Elevation
BP	Booster Pump
JA / 1515	Tank / Elevation
C / 1370	Junction / Elevation

1	Dischage	l/s
2	Pipe Length	m
3	Pipe Diameter	mm
4	Down stream hydraulic grade	
5	Up stream hydraulic grade	

Q	Production l/s
S	Difference between dynamic water level and static water level

TRANSMISSION LINE SCHEME EL RODEO



TRANSMISSION LINE SCHEME EL RODEO

LEGEND

2 / 1415 — Well NO. / Elevation

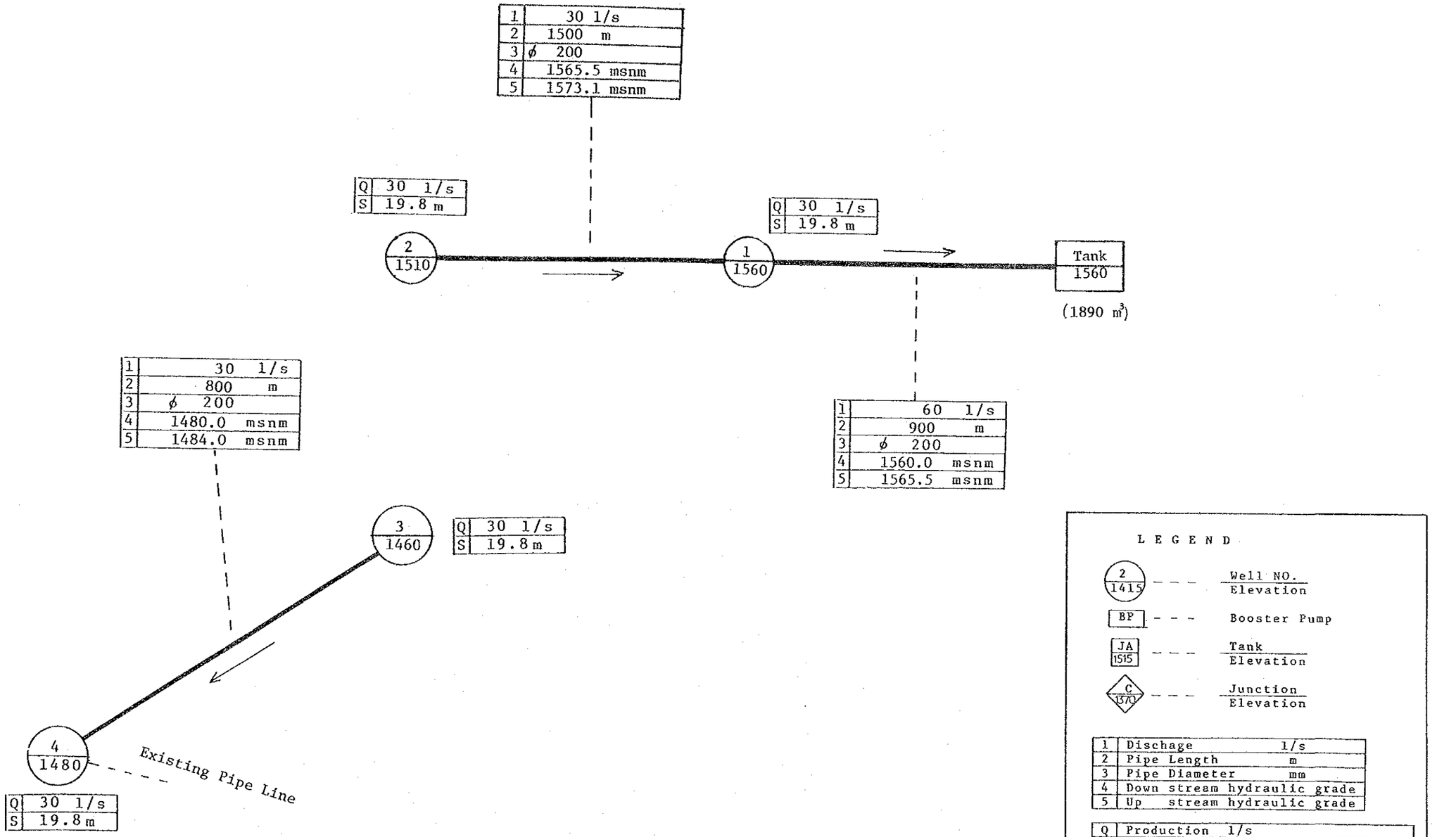
BP — Booster Pump

JA / 1515 — Tank / Elevation

C / 1570 — Junction / Elevation

1	Dischage	l/s
2	Pipe Length	m
3	Pipe Diameter	mm
4	Down stream hydraulic grade	
5	Up stream hydraulic grade	

Q	Production l/s
S	Difference between dynamic water level and static water level



TRANSMISSION LINE SCHEME HERMOSA